(2)

Final Report

MARCH 1989

EVT 23-88

RAIL TRANSPORTATION TEST OF THE M969A1 SERIES 5,000 GALLON SEMITRAILER TRUCK

DISTRIBUTION UNLIMITED

PREPARED FOR:
U.S. Army Tank-Automotive Command
ATTN: AMSTA-UEC
Warren, MI 48397-5000

US ARMY
ARMAMENT
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CHEMICAL COMMAND

US ARMY DEFENSE AMMUNITION
CENTER AND SCHOOL

EVALUATION DIVISION
SAVANNA, ILLINOIS 61074-9639

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The U.S. Army Defense Ammunition Center and School (USADACS), Evaluation Division (ATTN: SMCAC-DEV), was tasked by the U.S. Army Tank-Automotive Command (TACOM), Warren, MI to rail impact test the M969A1 Series 5000 gallon fuel Semitrailer Tank Truck. The semitrailer was tested on a flatcar secured with tiedown procedures supplied by Barnes & Reinecke, Inc. and tested to Association of American Railroads (AAR) test standards. Using these procedures, (tiedown and testing), the empty semitrailer tank truck passed the rail impact of 4, 6, 8 and 8 reverse miles per hour. A second set of tiedown procedures was suggested by USADACS reducing the number of cables and blocking. This modified procedure also satisfied the AAR test criteria. This report contains detailed information about these two tests.

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Evaluation Division
Savanna, IL 61074-9639

REPORT NO. EVT 23-88

RAIL TRANSPORTATION TEST OF THE M969A1 SERIES 5000 GALLON SEMITRAILER TANK TRUCK

TABLE OF CONTENTS

PART 1

INTRODUCTION

A. BACKGROUND

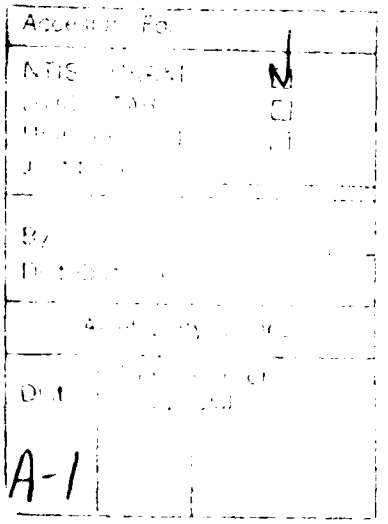
The U.S. Army Defense Ammunition Center and School (USADACS) was requested by U.S. Army Tank-Automotive Command (TACOM) to test the M969A1 series Fuel Tanker Semitrailer, to the American Association of Railroads test requirements for rail shipments. Two tiedown procedures were used to secure the semitrailer to the flatcar; one procedure was supplied by Barnes and Reinecke, Inc.; the second, using fewer tiedown cables, was designed by USADACS.

B. AUTHORITY

Testing has been accomplished in accordance with mission responsibility delegated by the U.S. Munitions and Chemical Command (AMCCOM). Reference is made to: Change 4, 4 October 1974., to AR 740-1, 23 April 1971, Storage and Supply Activity Operations and AMCCOM-R 10-17, 13 January 1986, Mission and Major Functions of USADACS.

C. OBJECTIVE

The objective of this test is to test the M969A1 Fuel Tanker Semitrailer for conformance to AAR railroad transportability test criteria.



PART 2

ATTENDEES

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Mark R. Waynick	U.S. Army Tank Automotive Command ATTN: AMSTA-GTM (Mark Waynick) Warren, MI 48397-5000 AV 786-5499 (313) 574-5499
Michael K. Williams	MTMCTEA P.O. Box 6276 Newport News, VA 23606 AV 927-4646 (804) 878-4646
Larry Himmelblau	Barnes & Reinecke, Inc. 2201 Estes Avenue Elk Grove, IL 60007 (312) 640-7200

PART 3

TEST PROCEDURE

RAIL IMPACT TEST

The M969A1 fuel tanker is positioned on flatcar. It is blocked, braced, and tied down in accordance with proposed procedures. Equipment needed to perform the test includes the specimen (hammer) car, five empty railroad cars connected together to serve as the anvil, and a railroad locomotive. The anvil cars are positioned on a level section of track or with air and hand brakes set, and the draft gear compressed. The locomotive switch engineer pulls the specimen car 300 to 500 feet away from the anvil cars and then pushes the specimen car toward the anvil at a predetermined velocity, releasing the specimen car about 200 feet from the anvil cars, allowing it to roll freely along the track until it strikes the anvil. This is one impact. This process is repeated at speeds of 4, 6 and 8 miles per hour (mph) in one direction, and then the specimen car is rotated 180 degrees and impacted at 8 mph. Impact velocity is measured using electronic counter-timer. The trigger is generated by the specimen car breaking two light beams. The first broken light beam starts the counter and the second stops the counter. The light beams are spaced 11 feet apart. The impact velocity is calculated from time measured by the counter-timer and knowing the distance along the track between the start and stop light beams.

PART 4

TEST EQUIPMENT

1. Test Specimen

   a. Fuel Tanker, M969A1
      1. Weight: 15,400 pounds
      2. Length: 368 inches
      3. Width: 96 inches
      4. Height: 104 inches empty

   b. Flat car, 50 feet long
      1. Car number: SLSF2152
      2. Capacity: 110,000 pounds
      3. Load Limit: 118,000 pounds
      4. Light Weight: 58,200 pounds

2. Track Timer

3. DATA ACQUISITION
   a. Accelerometers
   b. Telemetry Package
   c. Honeywell 5600c tape recorder

4. DATA ANALYSIS EQUIPMENT
   a. Zenith AT microcompute
   b. Software - ASYST

PART 5

TEST RESULTS

Two series of impact tests were performed. One series of impacts was accomplished with the test specimen tied down using trailer manufacturer procedures; and in the second series, the tie down was accomplished using USADACS procedures. The following sections contain the results of these tests.

TEST NO. 1 Barnes & Reinecke tiedown procedure.

TEST FLATCAR No. SLS2152 LTWT. 58,000 pounds

Lading and dunnage	WT:	16,200	pounds
TOTAL SPECIMEN	WT:	74,400	pounds
ANVIL (5 cars)	WT:	250,000	pounds

IMPACT No.	End Struck	Velocity	Remarks
1	Forward	5.95 mph	1/4" shift at stanchion
2	Forward	6.55 mph	1/8" shift at stanchion
3	Forward	8.25 mph	7/16" shift at stanchion
4	Reverse	8.15 mph	7/8" shift at stanchion

SULTS OF THE RAIL IMPACT TEST ON
5 GALLON FUEL TRAILER WITH MAX. CABLES
DATE: 12 MAY 1988

TAPE CHANNEL 3 : LONGITUDINAL ACCELERATION ON SILL

TEST	SPEED MPH	PEAK VALUE G S	DURATION MILLISECONDS	AREA G S-SECONDS
IMPACT 1	5.95	1.64	70.75	.07
IMPACT 2	6.55	1.44	61.40	.05
IMPACT 3	8.25	*****	*****	*****
IMPACT 4 (REVERSE)	8.15	-2.12	54.17	.07

TAPE CHANNEL 4 : VERTICAL ACCELERATION ON SILL

TEST	SPEED MPH	PEAK VALUE G'S	DURATION MILLISECONDS	AREA G S-SECONDS
IMPACT 1	5.95	*****	*****	*****
IMPACT 2	6.55	*****	*****	*****
IMPACT 3	8.25	*****	*****	*****
IMPACT 4 (REVERSE)	8.15	.32	51.86	.01

TAPE CHANNEL 5 : LONGITUDINAL ACCELERATION ON TANKER FRAME

TEST	SPEED MPH	PEAK VALUE G'S	DURATION MILLISECONDS	AREA G S-SECONDS
IMPACT 1	5.95	.01	38.38	.00
IMPACT 2	6.55	.01	61.20	.00
IMPACT 3	8.25	-.01	60.13	.00
IMPACT 4 (REVERSE)	8.15	*****	*****	*****

TAPE CHANNEL 6 : RAIL COUPLER FORCE

TEST	SPEED MPH	PEAK VALUE POUNDS	DURATION MILLISECONDS	AREA POUNDS-SECONDS
IMPACT 1	5.95	316488.00	126.97	29913.19
IMPACT 2	6.55	293088.22	98.67	19873.24
IMPACT 3	8.25	362277.03	103.10	27147.05
IMPACT 4 (REVERSE)	8.15	264685.56	90.58	17344.57

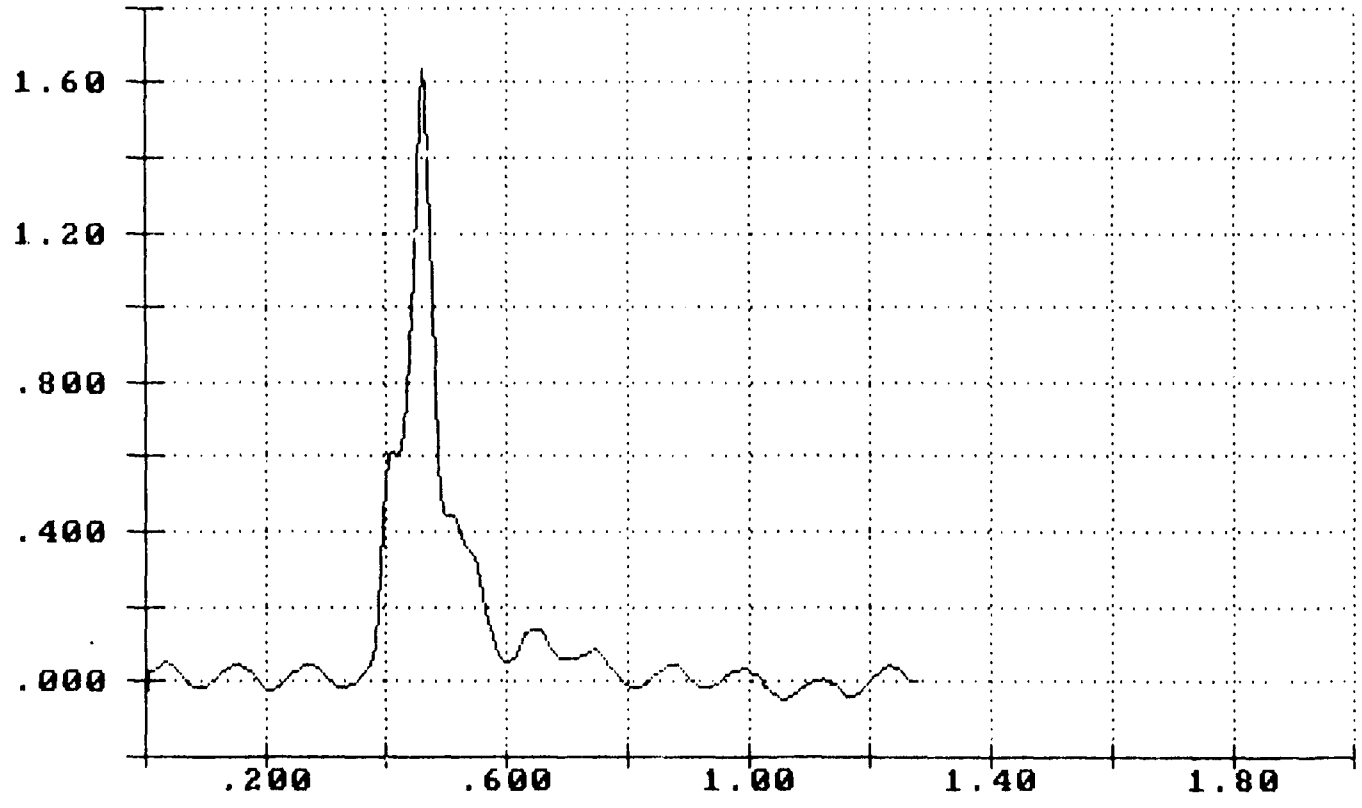
TAPE CHANNEL 7 : VERTICAL ACCELERATION ON TANKER FRAME

TEST	SPEED MPH	PEAK VALUE G'S	DURATION MILLISECONDS	AREA G'S-SECONDS
IMPACT 1	5.95	-.25	72.77	.01
IMPACT 2	6.55	-.22	55.07	.11
IMPACT 3	8.25	*****	*****	*****
IMPACT 4 (REVERSE)	8.15	.35	76.61	.02

NOTES:

*****: DATA NOT AVAILABLE.

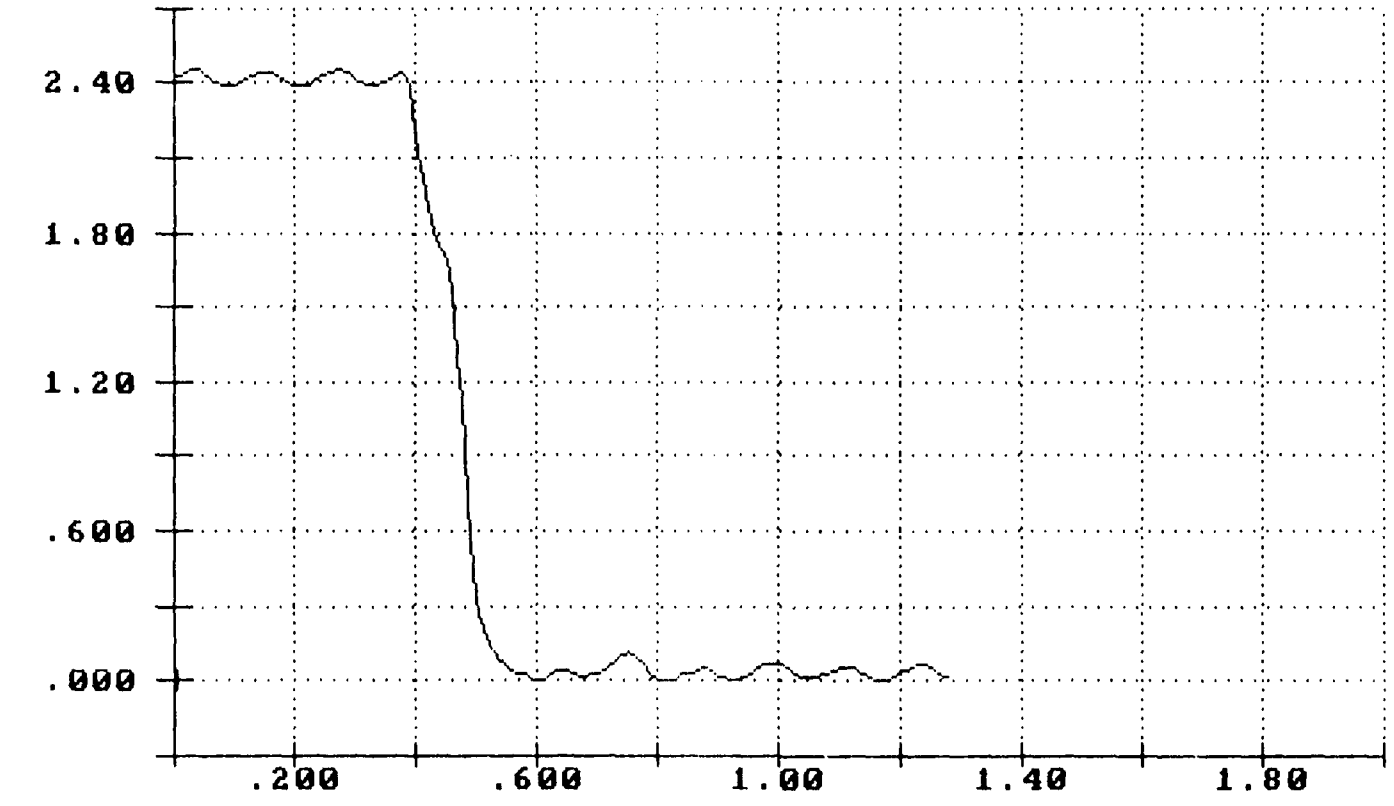
RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH MAX. CABLES (IMPACT 1)



LONGITUDINAL ACCELERATION ON SILL IN G'S X 1.00

Time in Seconds
X 1.00

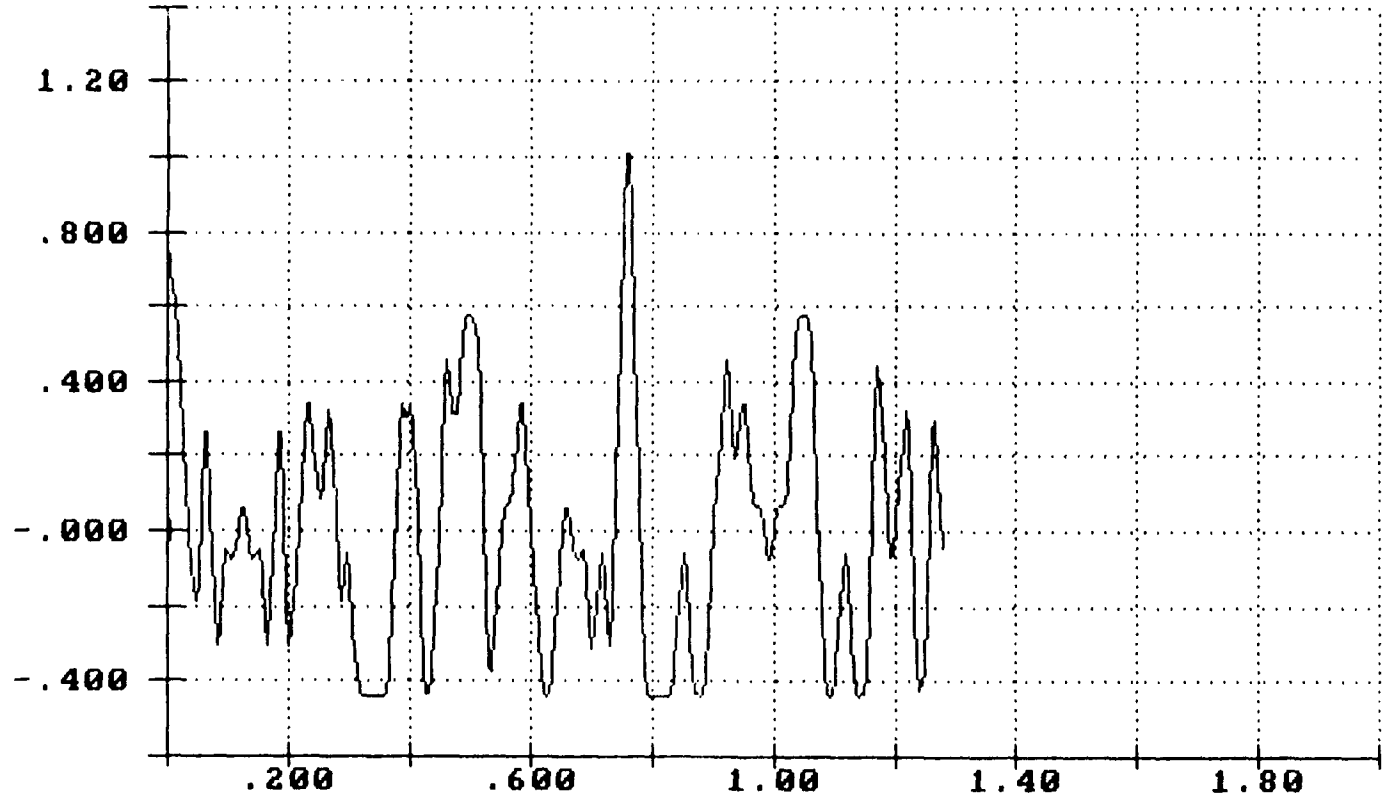
RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH MAX. CABLES (IMPACT 1)



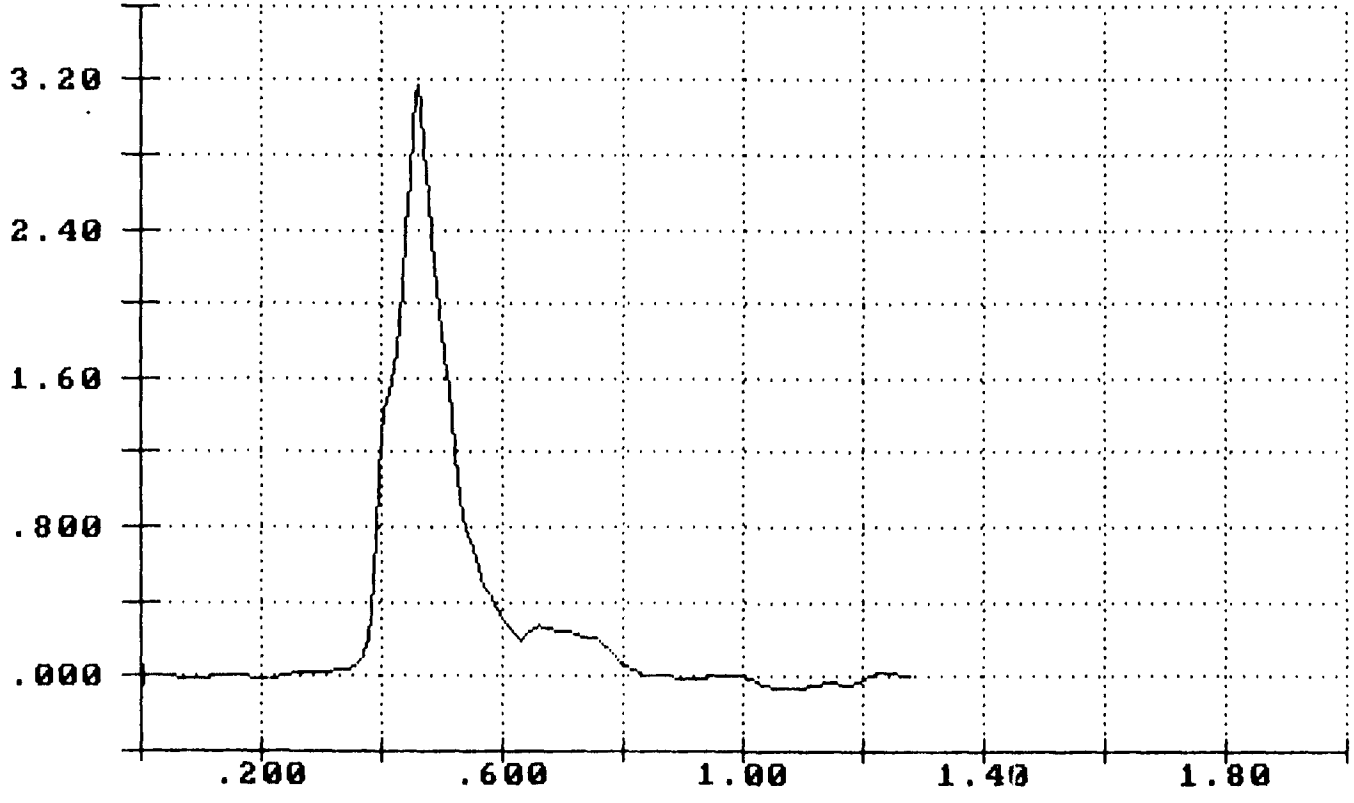
VERTICAL ACCELERATION ON SILL IN G'S X 1.00

Time in Seconds
X 1.00

RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH MAX. CABLES (IMPACT 1)



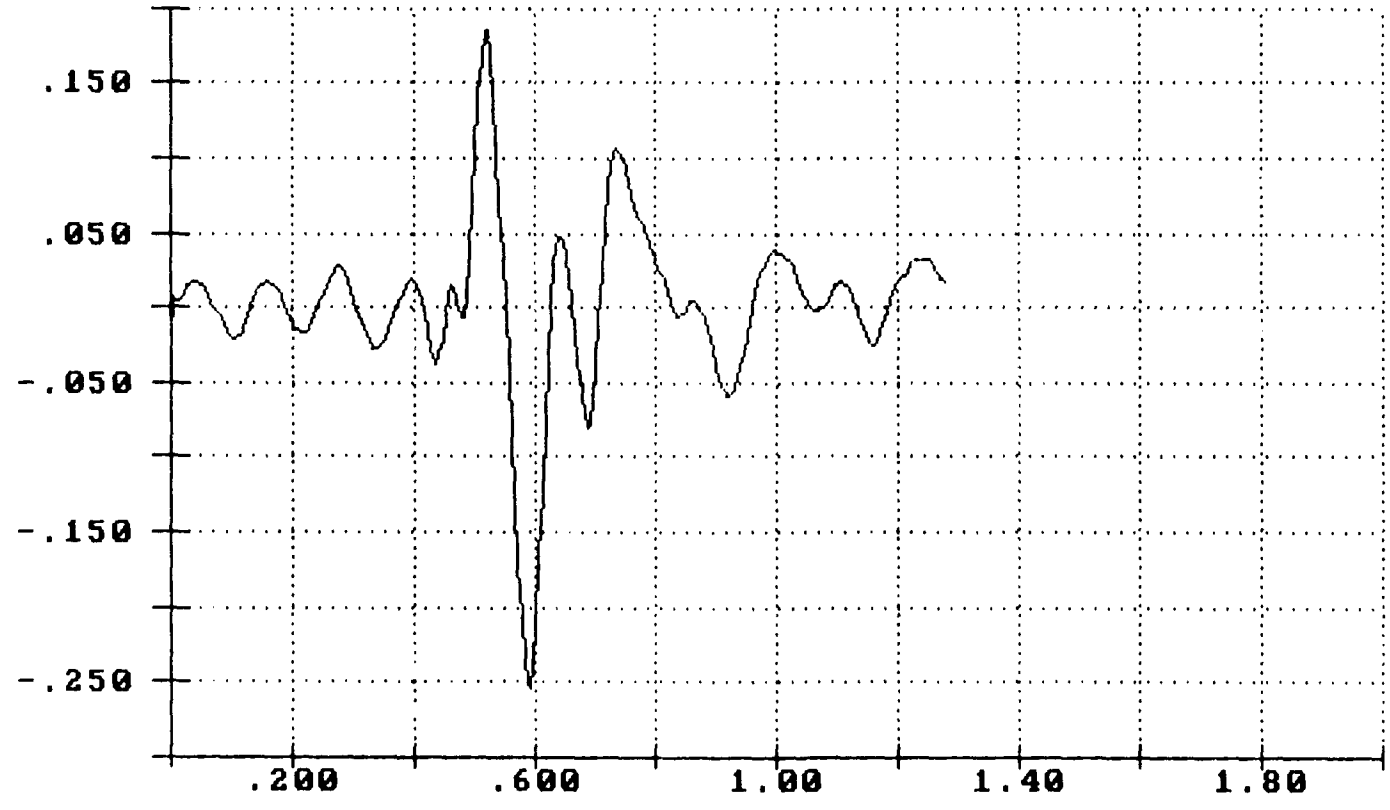
RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH MAX. CABLES (IMPACT 1)



RAIL COUPLER FORCE
IN POUNDS X 100000.00

Time in Seconds
X 1.00

RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH MAX. CABLES (IMPACT 1)



RESULTS OF THE RAIL IMPACT TEST ON
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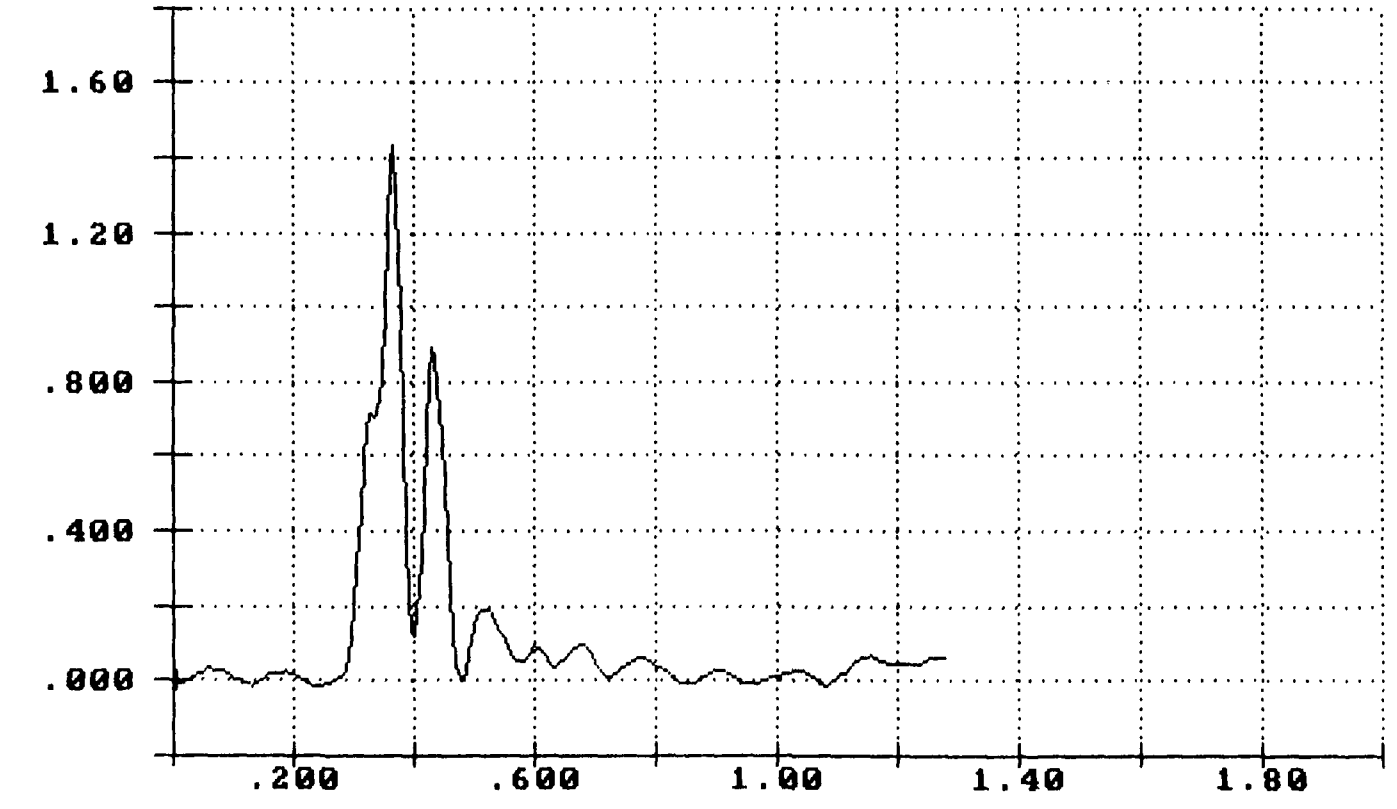
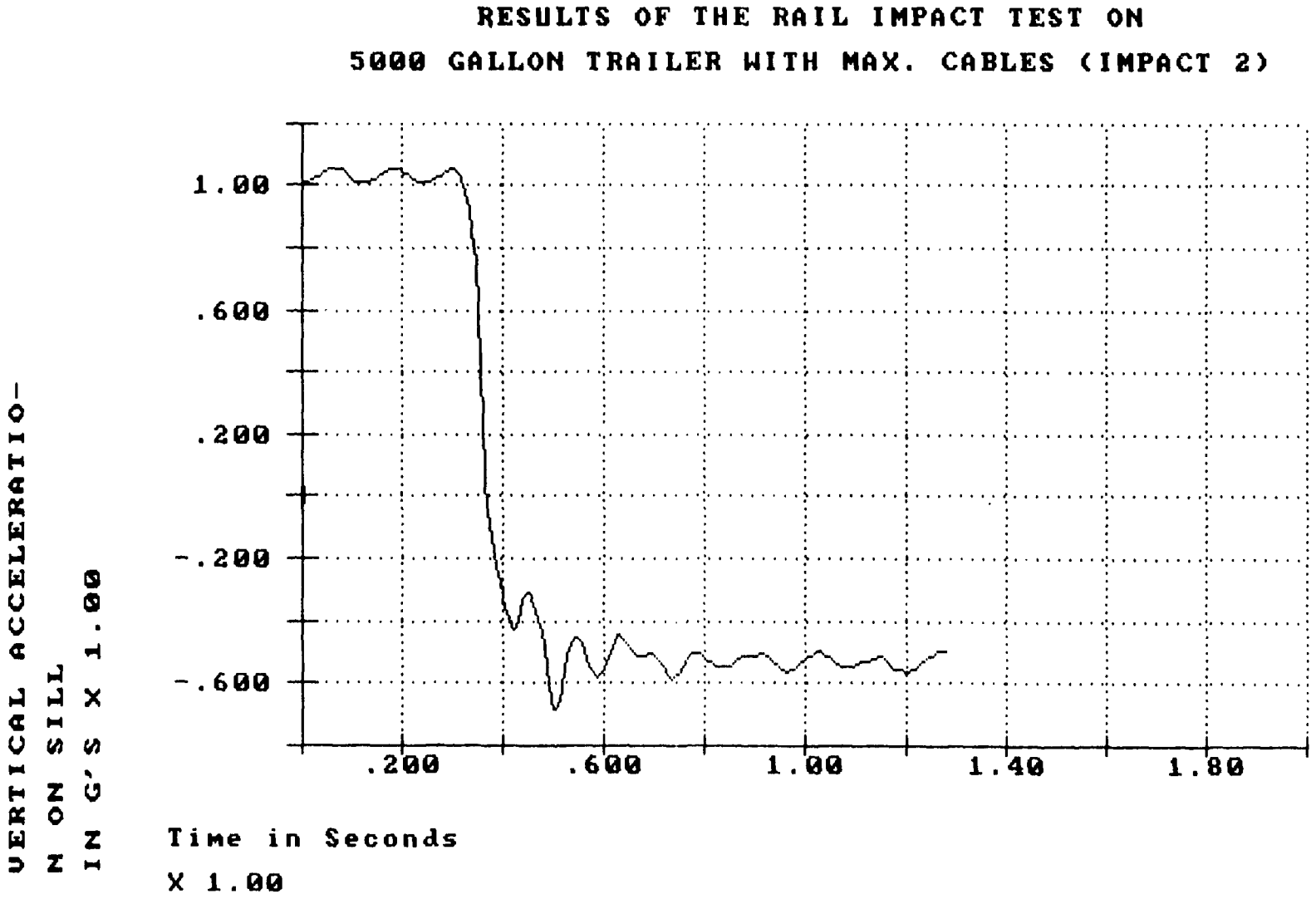
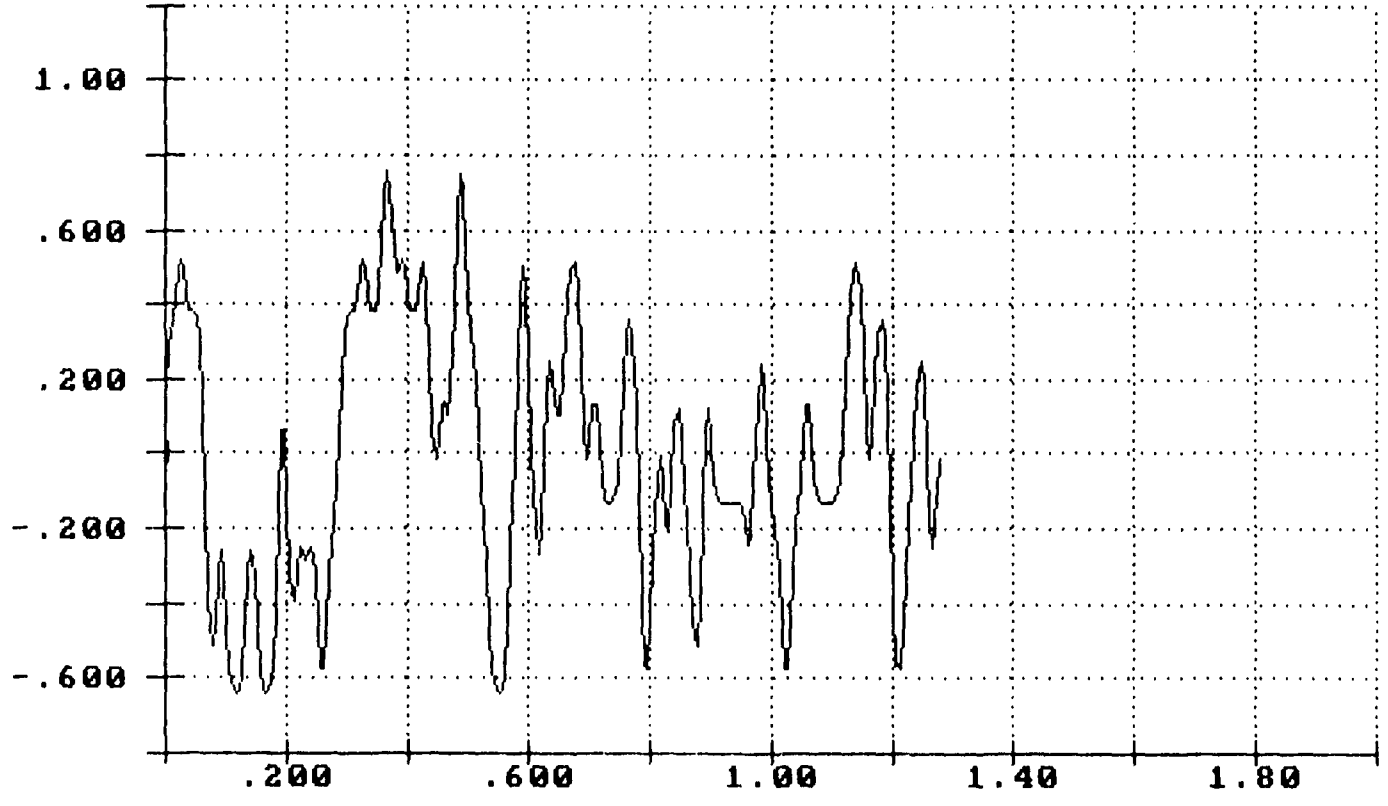


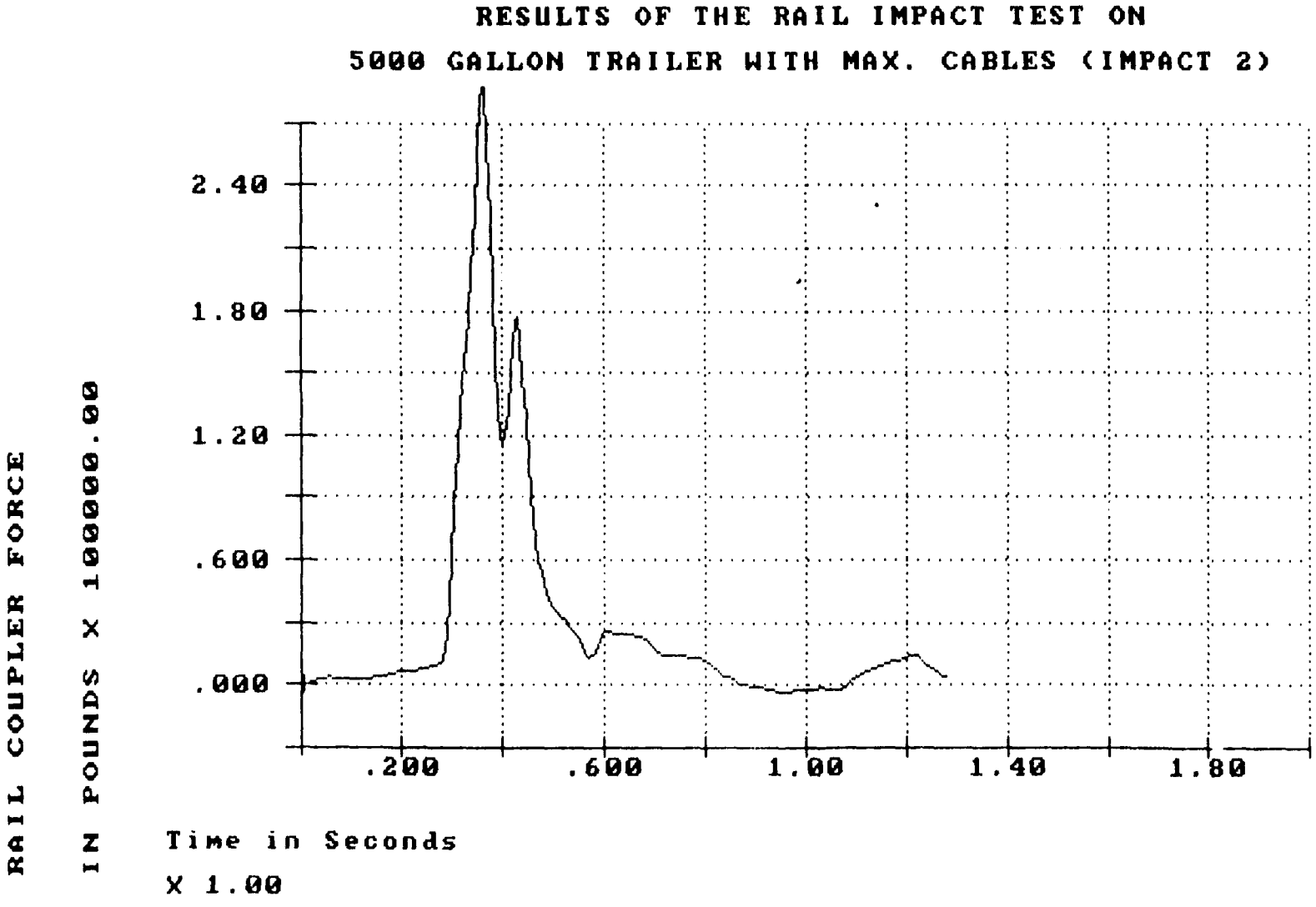

RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH MAX. CABLES (IMPACT 2)
1.00
.600
.200
-.200
-.600
.200
.600
1.00
1.40
1.80
VERTICAL ACCELERATIO-
N ON SILL
IN G'S X 1.00
Time in Seconds
X 1.00

RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH MAX. CABLES (IMPACT 2)

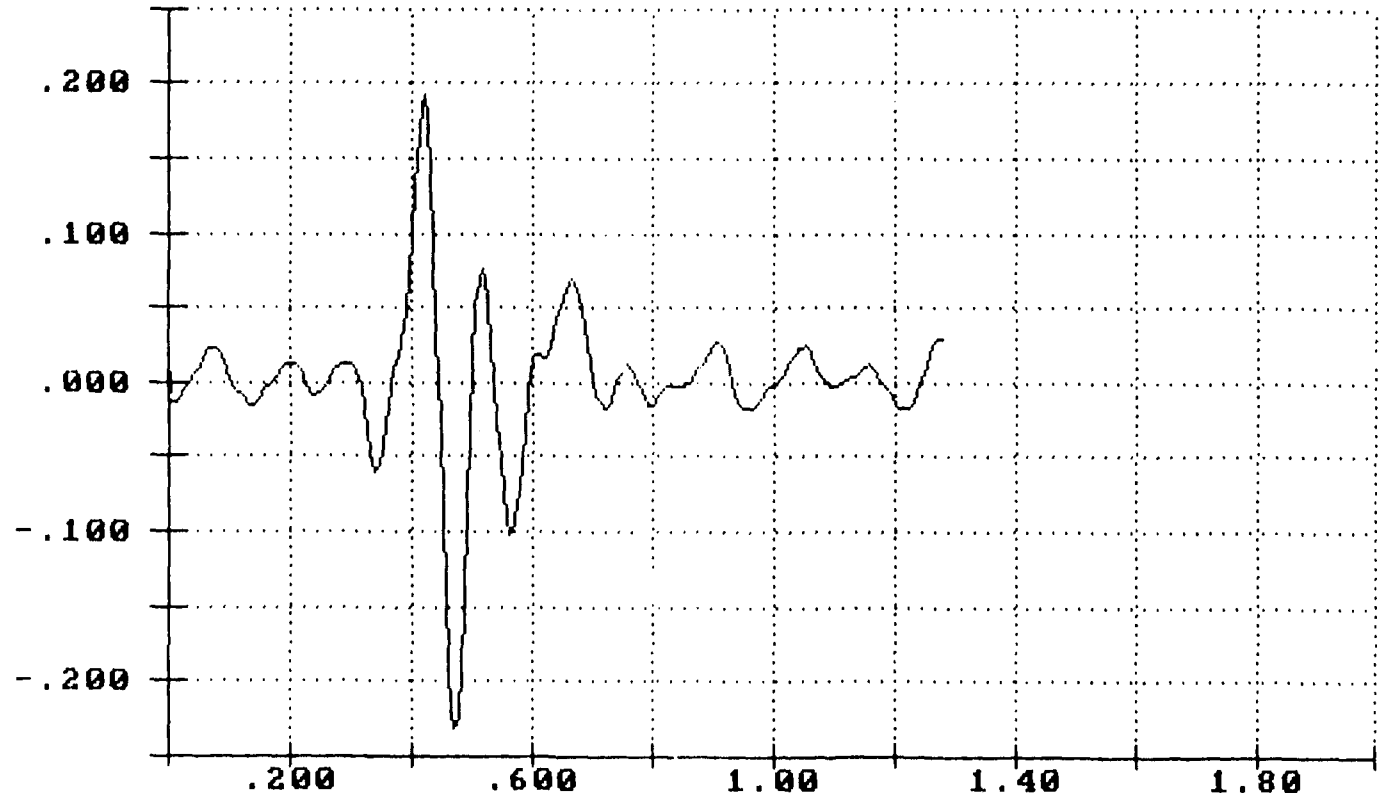


LONGITUDINAL ACCELER-
ATION ON TANKER FRAM
IN G'S X .01

Time in Seconds
X 1.00


RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH MAX. CABLES (IMPACT 2)
RAIL COUPLER FORCE
IN POUNDS X 100000.00
2.40
1.80
1.20
.600
.000
.200
.600
1.00
1.40
1.80
Time in Seconds
X 1.00

RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH MAX. CABLES (IMPACT 2)



RESULTS OF THE RAIL IMPACT TEST ON
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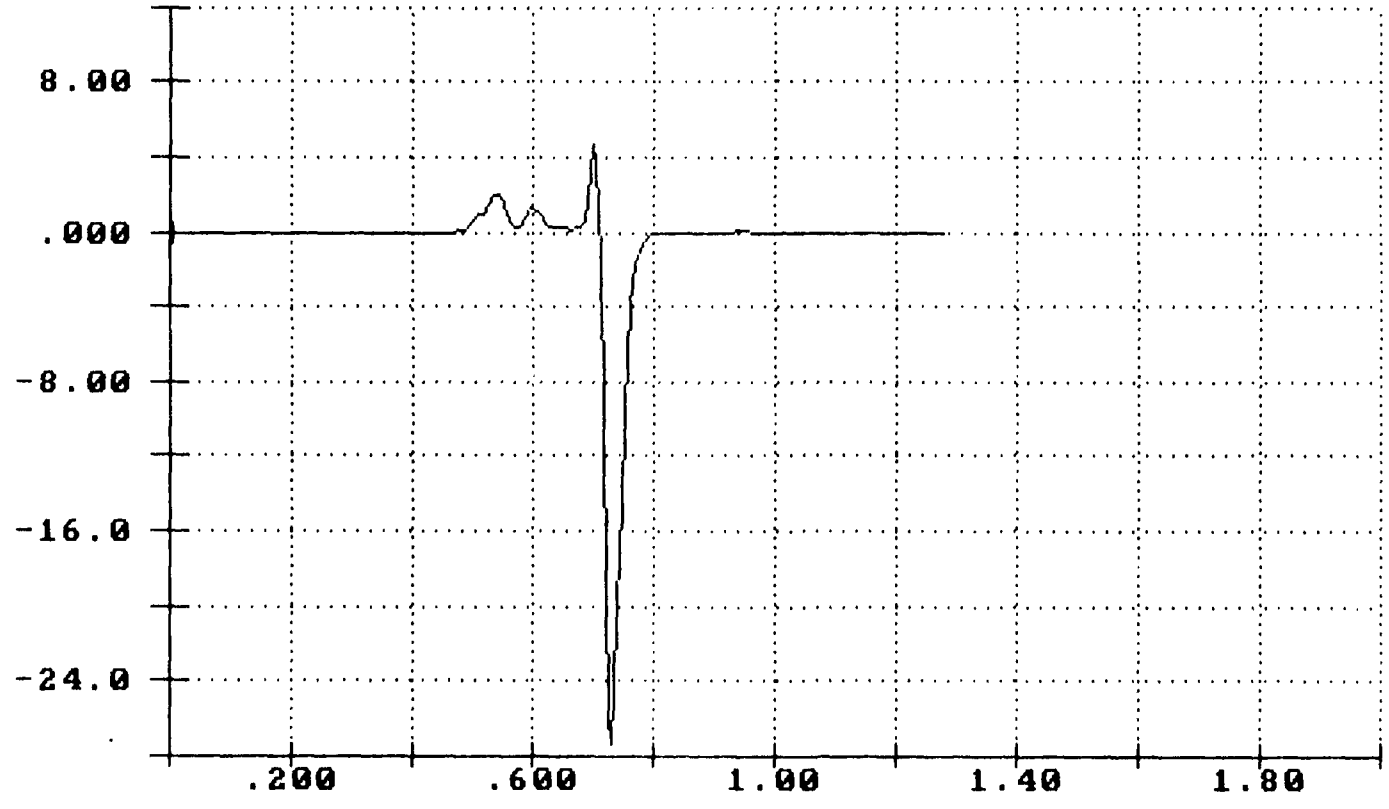
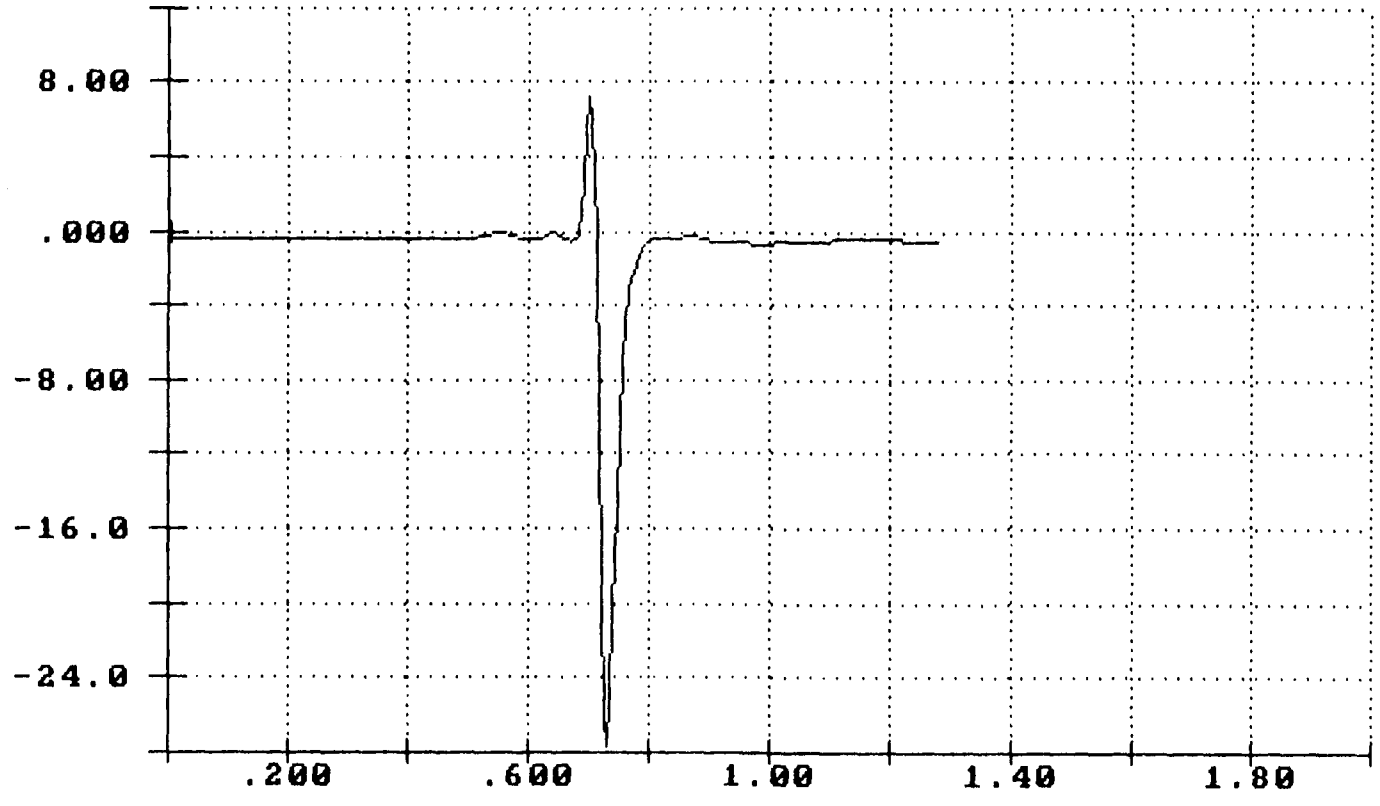


RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER W'TH MAX. CABLES (IMPACT 3)



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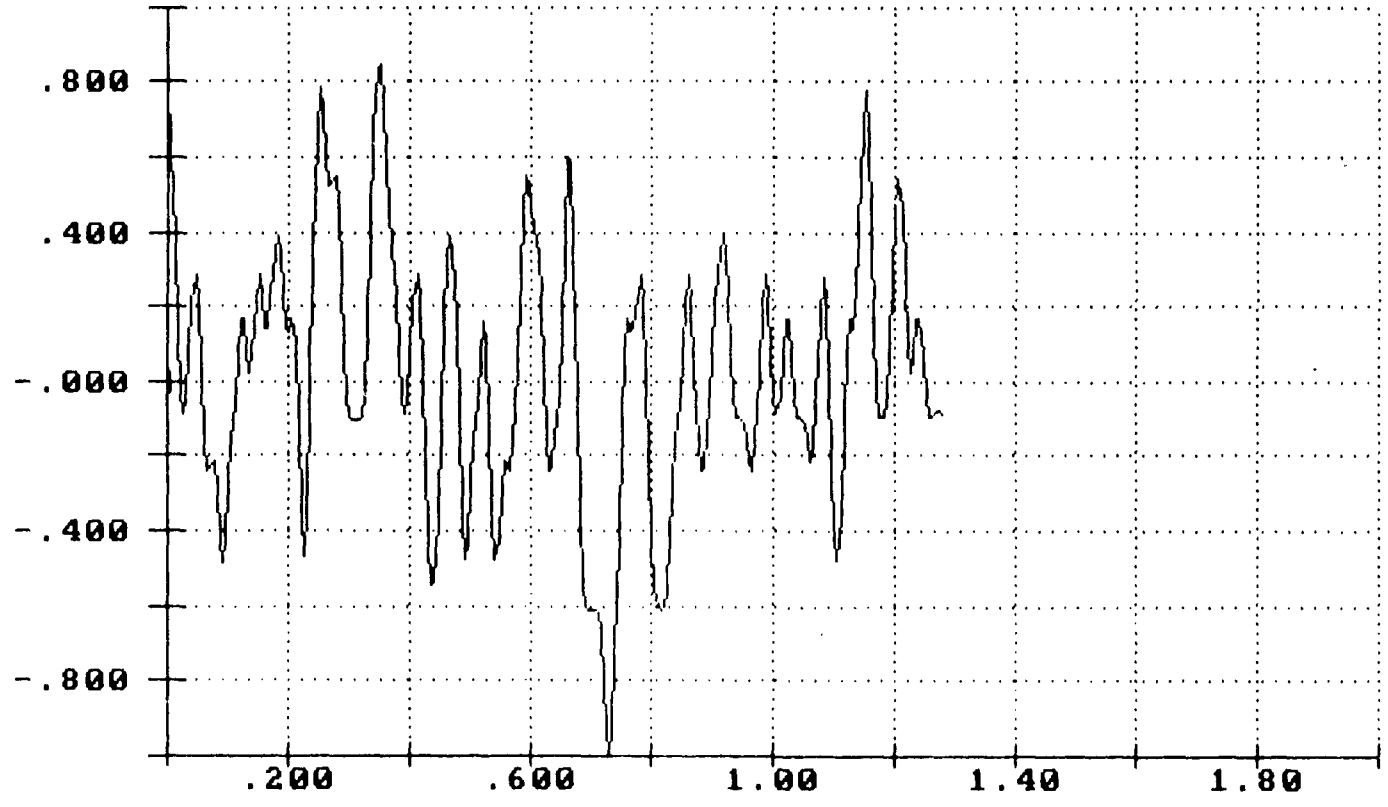
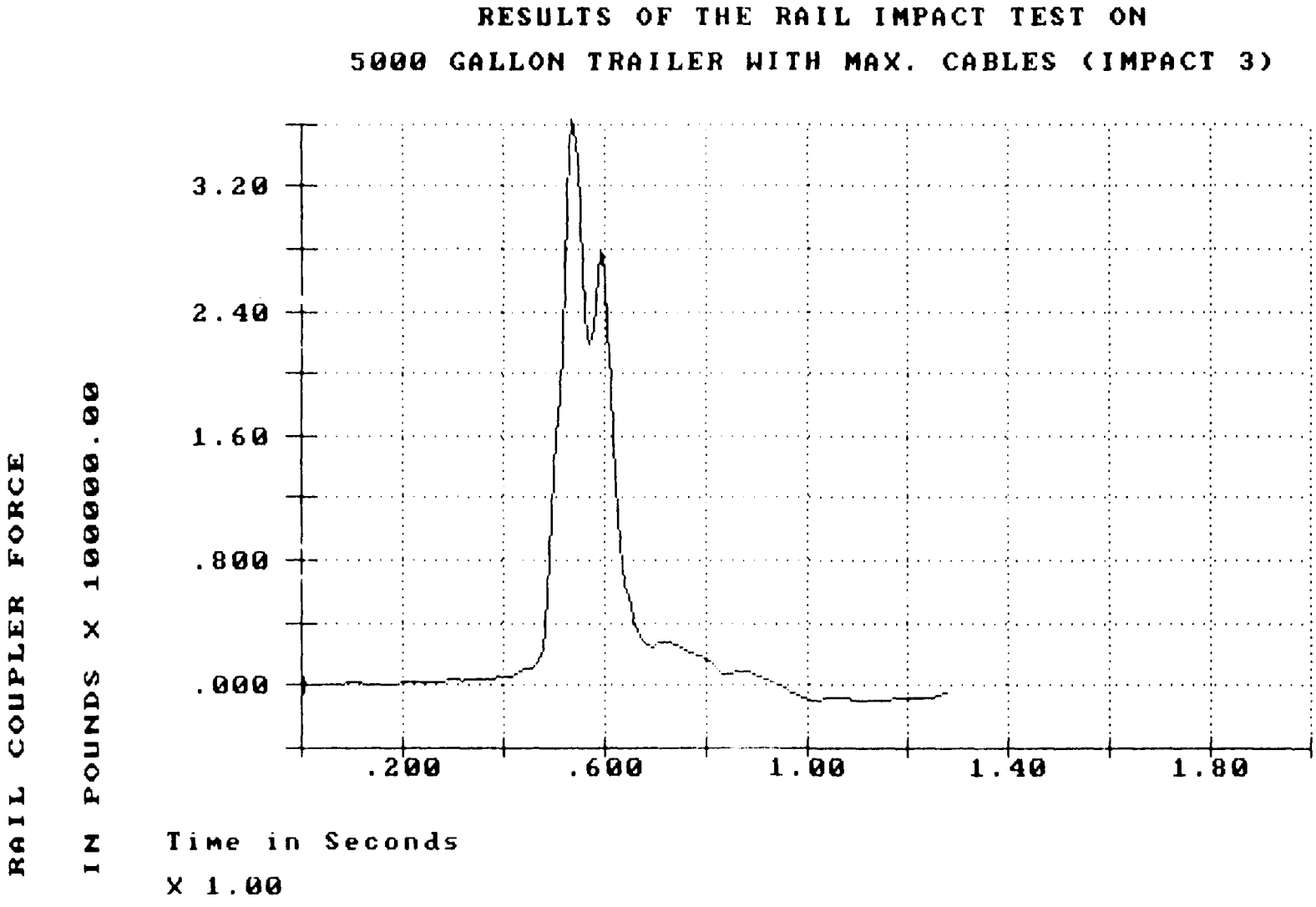
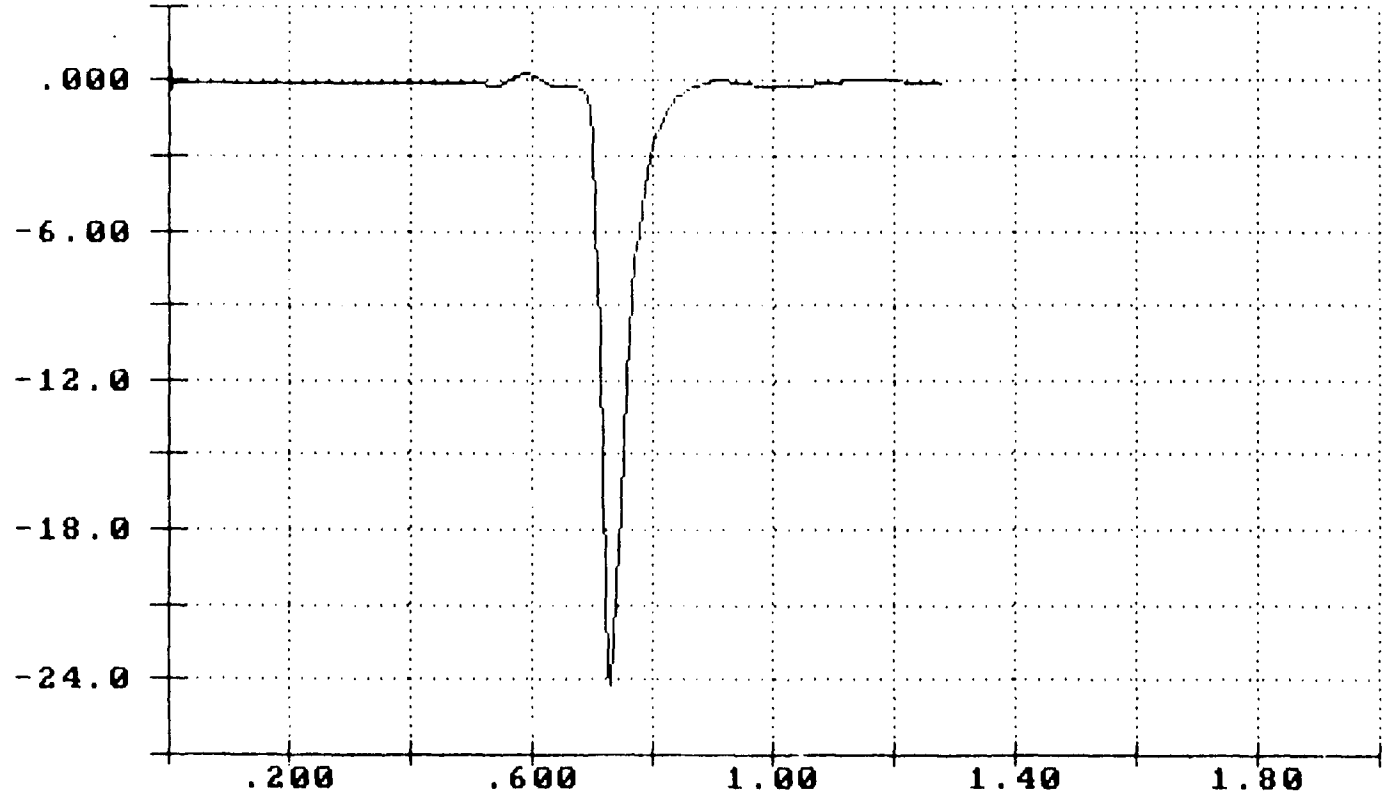



RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH MAX. CABLES (IMPACT 3)
RAIL COUPLER FORCE
IN POUNDS X 100000.00
3.20
2.40
1.60
.800
.000
.200
.600
1.00
1.40
1.80
Time in Seconds
X 1.00

RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH MAX. CABLES (IMPACT 3)



RESULTS OF THE RAIL IMPACT TEST ON
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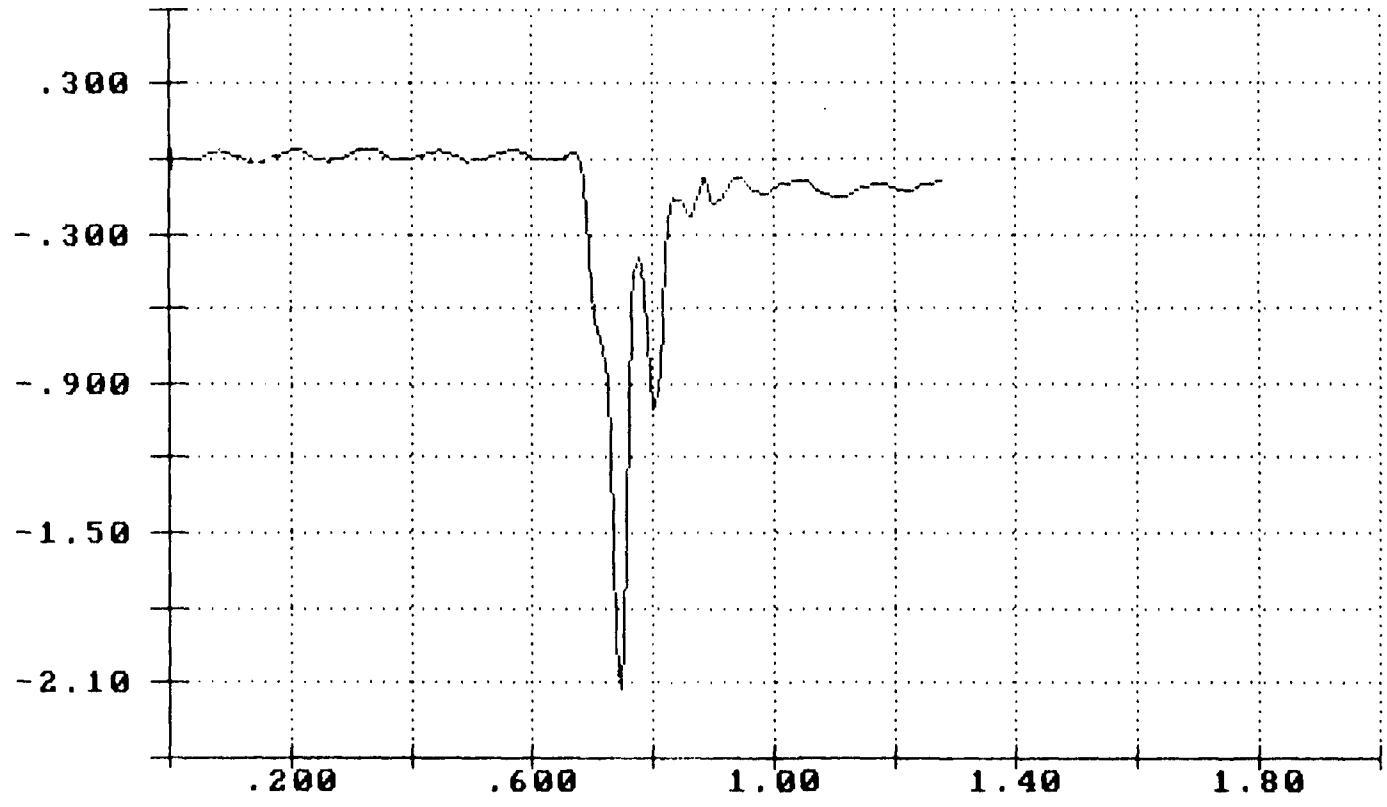
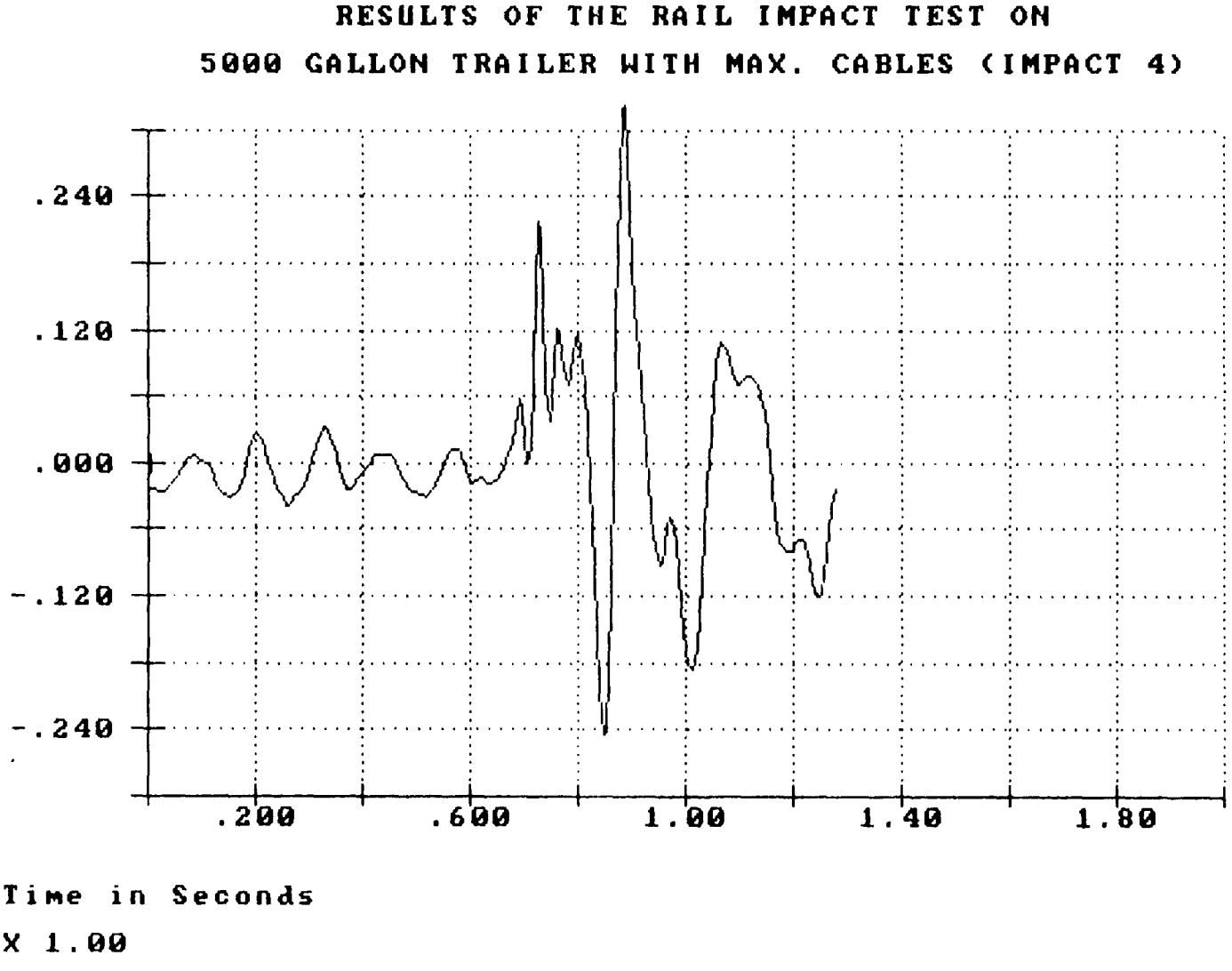
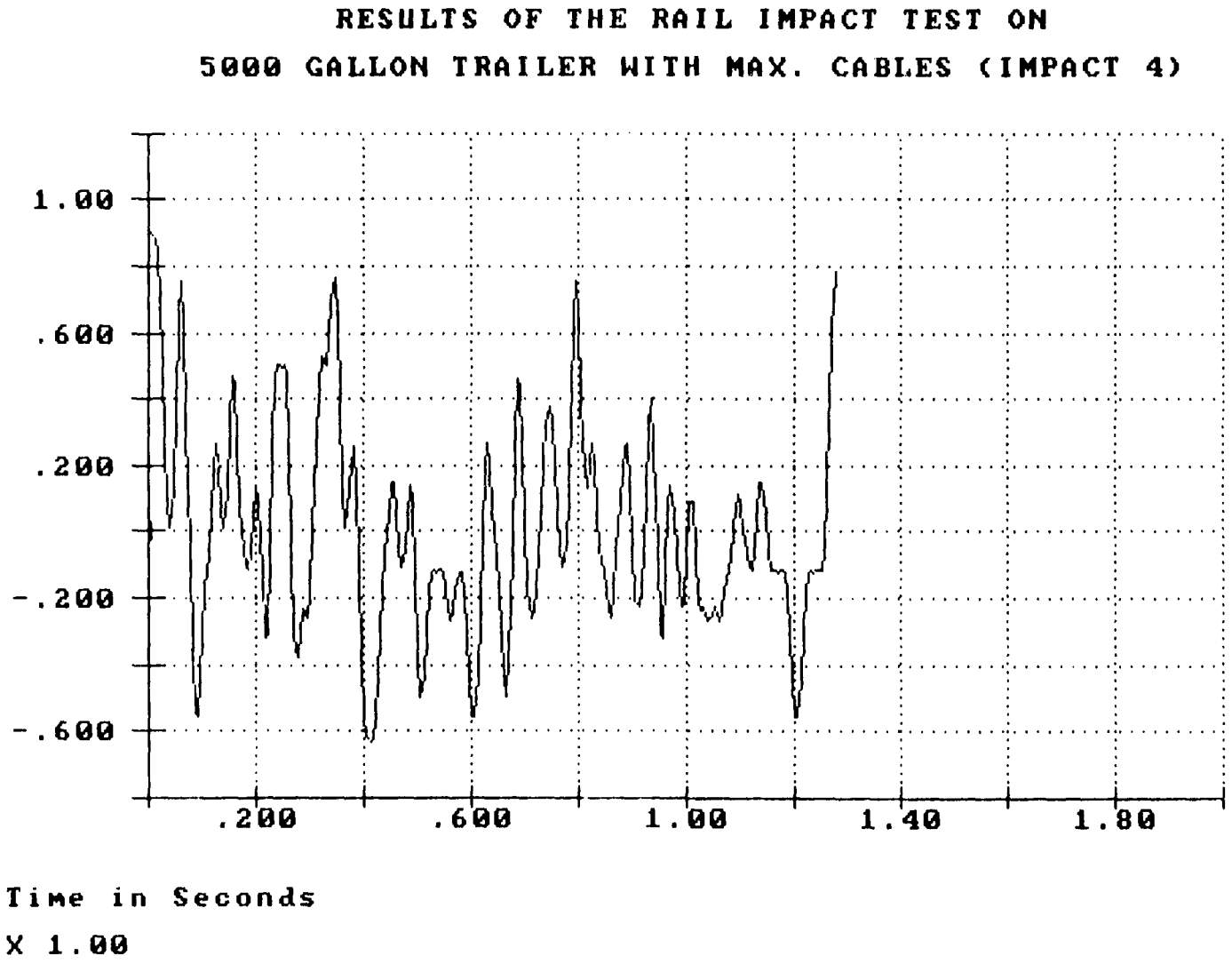


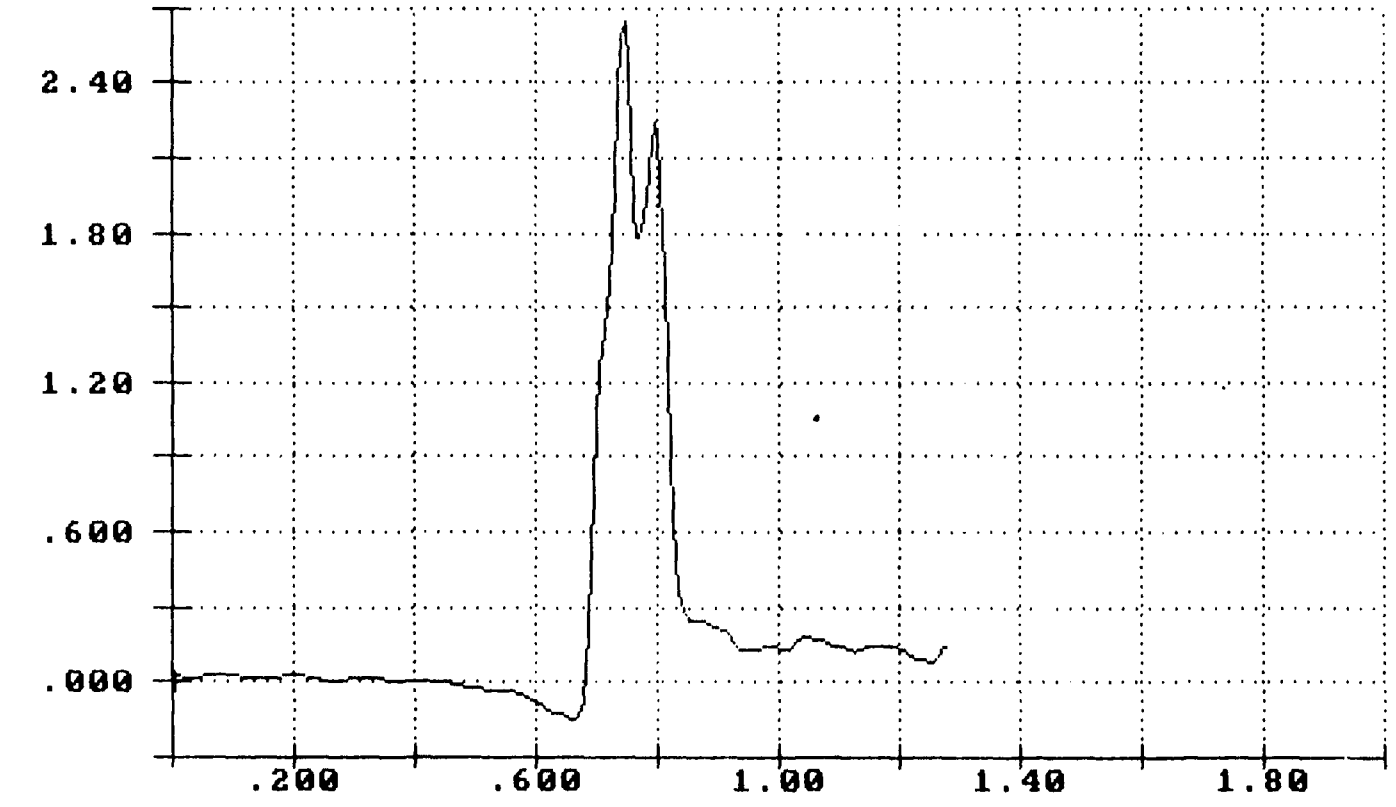
LONGITUDINAL ACCELER-
ATION ON SILL
IN G'S X 1.00

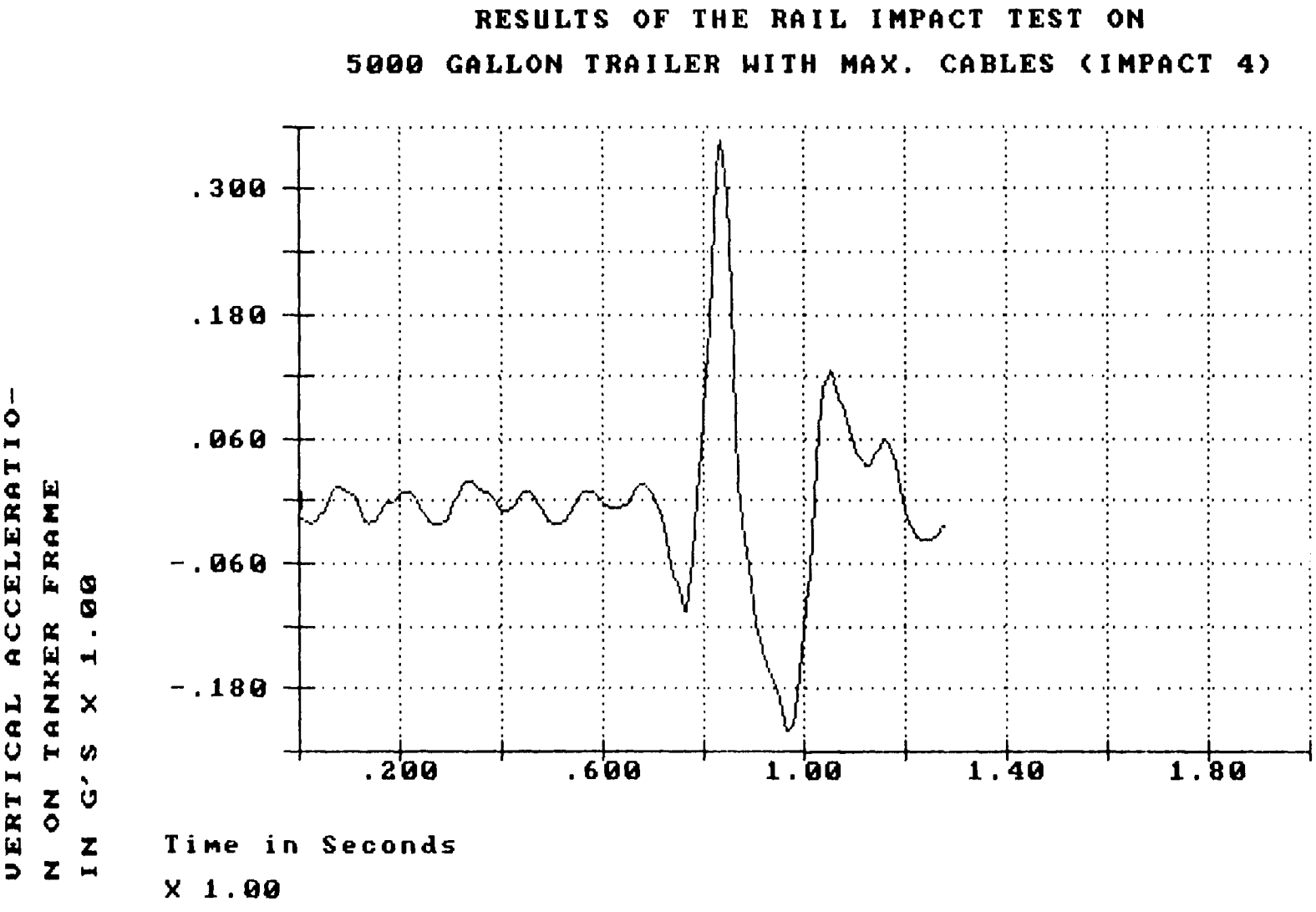
Time in Seconds
X 1.00


RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH MAX. CABLES (IMPACT 4)
.240
.120
.000
-.120
-.240
.200
.600
1.00
1.40
1.80
VERTICAL ACCELERATIO-
N ON SILL
IN G'S X 1.00
Time in Seconds
X 1.00


RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH MAX. CABLES (IMPACT 4)
1.00
.600
.200
-.200
-.600
.200
.600
1.00
1.40
1.80
LONGITUDINAL ACCELER-
ATION ON TANKER FRAM
IN G'S X .01
Time in Seconds
X 1.00

RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH MAX. CABLES (IMPACT 4)




RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH MAX. CABLES (IMPACT 4)
.300
.180
.060
-.060
-.180
.200
.600
1.00
1.40
1.80
VERTICAL ACCELERATIO-
N ON TANKER FRAME
IN G'S X 1.00
Time in Seconds
X 1.00

TEST No. 2 Barnes & Reinecke tiedown procedure with four cables and four axel stands removed.

TEST FLATCAR No. SLS2152 LTWT: 58,200 pounds

LADING and DUNNAGE WT: 16,200 pounds
TOTAL SPECIMEN WT: 74,400 pounds
ANVIL (5 cars) WT: 220,000 pounds

IMPACT No.	End Struck	Velocity	Remarks
1.	Forward	4.45	1/2" forward movement at stanchion
2.	Forward	6.55	3/8" forward movement at stanchion
3.	Forward	9.25	1/4" forward movement at stanchion
4.	Reverse	8.28	3/4" reverse movement at stanchion

RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON FUEL TRAILER WITH FEWER CABLES
DATE: 12 MAY 1988

TAPE CHANNEL 3 : LONGITUDINAL ACCELERATION ON SILL

TEST	SPEED MPH	PEAK VALUE G'S	DURATION MILLISECONDS	AREA G'S-SECONDS
IMPACT 1	4.45	1.02	101.07	.07
IMPACT 2	6.55	6.62	52.18	.21
IMPACT 3	8.25	-16.81	38.95	.38
IMPACT 4 (REVERSE)	8.28	9.12	50.37	.27

TAPE CHANNEL 4 : VERTICAL ACCELERATION ON SILL

TEST	SPEED MPH	PEAK VALUE G'S	DURATION MILLISECONDS	AREA G'S-SECONDS
IMPACT 1	4.45	.19	54.23	.01
IMPACT 2	6.55	9.23	51.23	.29
IMPACT 3	8.25	-16.66	38.20	.37
IMPACT 4 (REVERSE)	8.28	12.94	50.93	.38

TAPE CHANNEL 5 : LONGITUDINAL ACCELERATION ON TANKER FRAME

TEST	SPEED MPH	PEAK VALUE G'S	DURATION MILLISECONDS	AREA G'S-SECONDS
IMPACT 1	4.45	-.01	50.35	.00
IMPACT 2	6.55	.01	40.28	.00
IMPACT 3	8.25	.01	60.43	.00
IMPACT 4 (REVERSE)	8.28	.01	39.14	.00

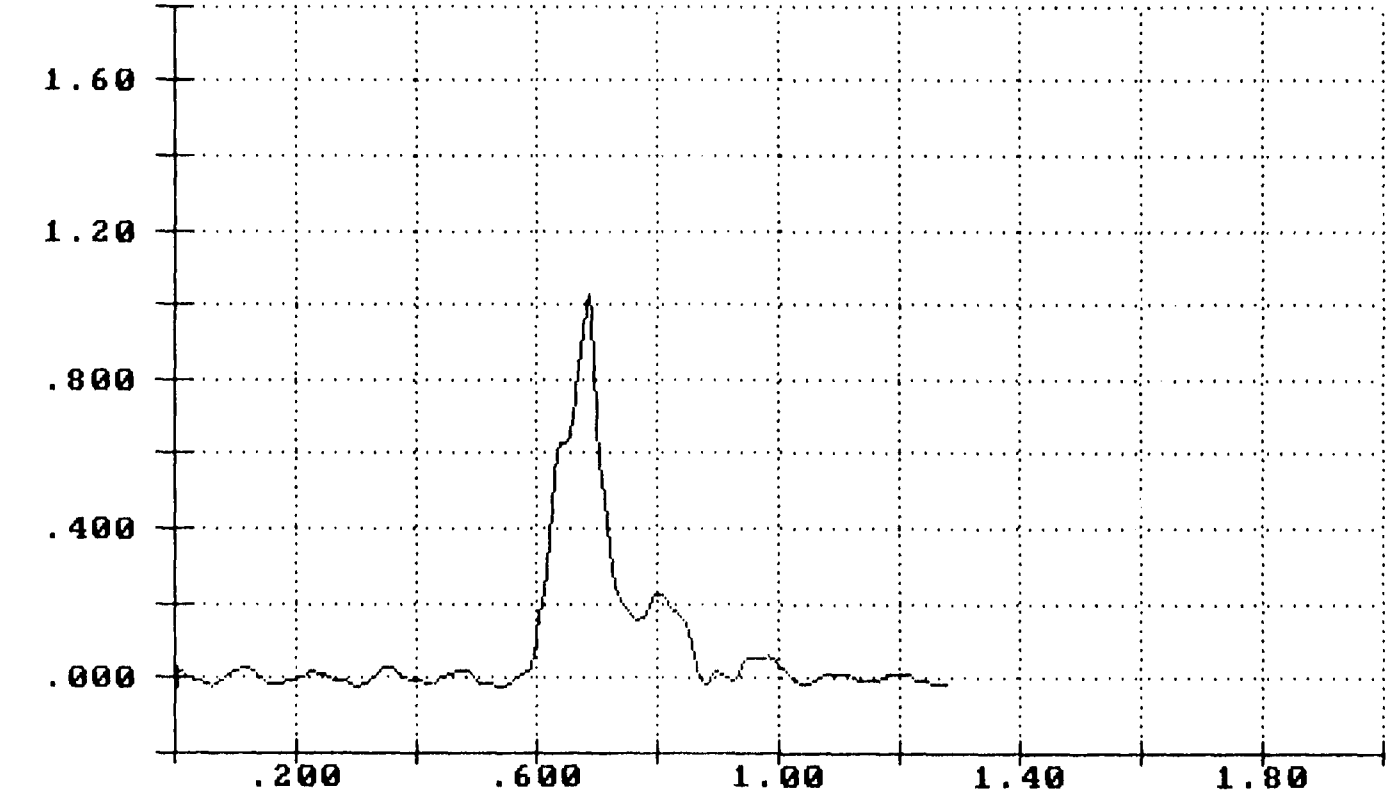
TAPE CHANNEL 6 : RAIL COUPLER FORCE

TEST	SPEED MPH	PEAK VALUE POUNDS	DURATION MILLISECONDS	AREA POUNDS-SECONDS
IMPACT 1	4.45	254332.03	170.29	25160.77
IMPACT 2	6.55	254207.44	143.04	25671.92
IMPACT 3	8.25	379753.56	118.51	29991.30
IMPACT 4 (REVERSE)	8.28	314786.78	84.01	20060.74

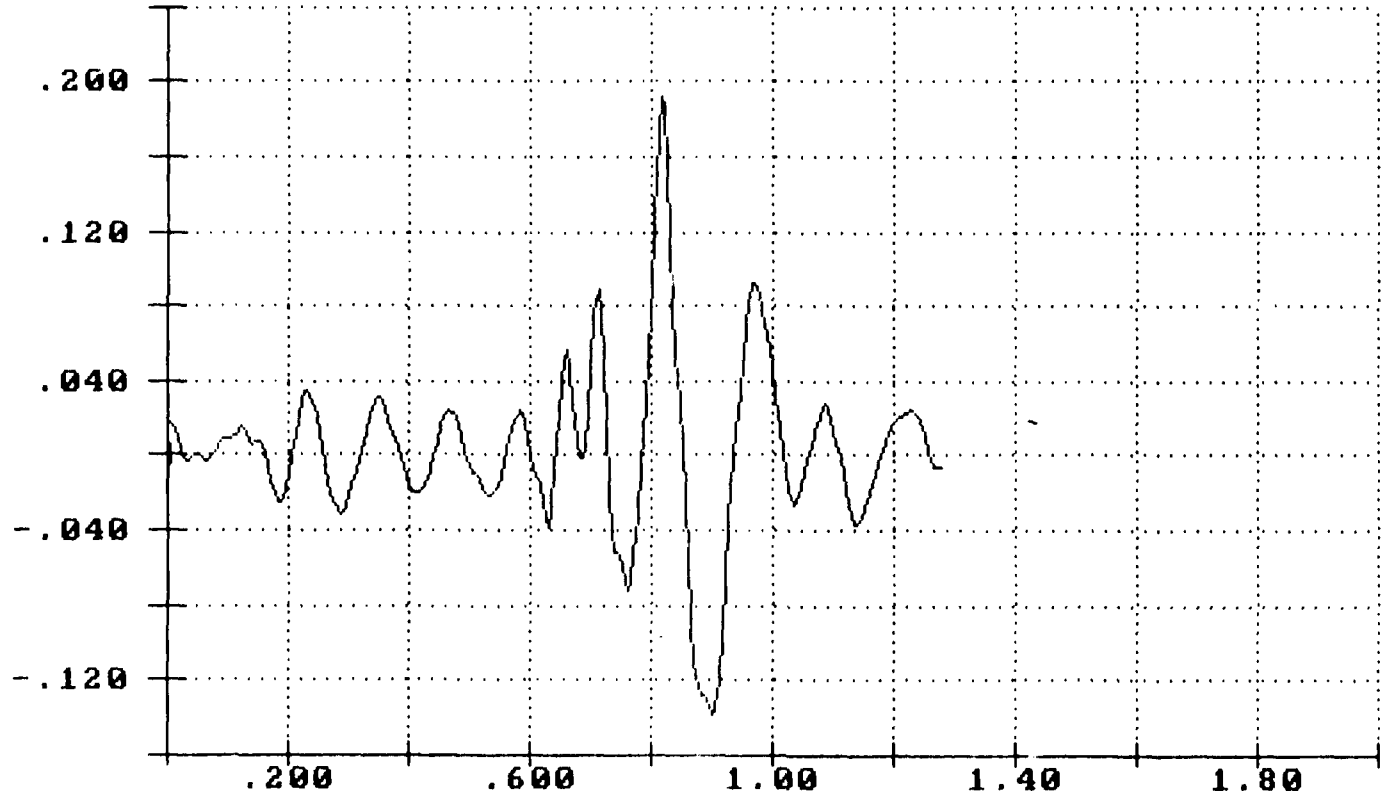
TAPE CHANNEL 7 : VERTICAL ACCELERATION ON TANKER FRAME

TEST	SPEED MPH	PEAK VALUE G'S	DURATION MILLISECONDS	AREA G S-SECONDS
IMPACT 1	4.45	.36	74.57	.02
IMPACT 2	6.55	-.68	72.56	.03
IMPACT 3	8.25	-14.69	68.46	.63
IMPACT 4 (REVERSE)	8.28	-.39	56.15	.01

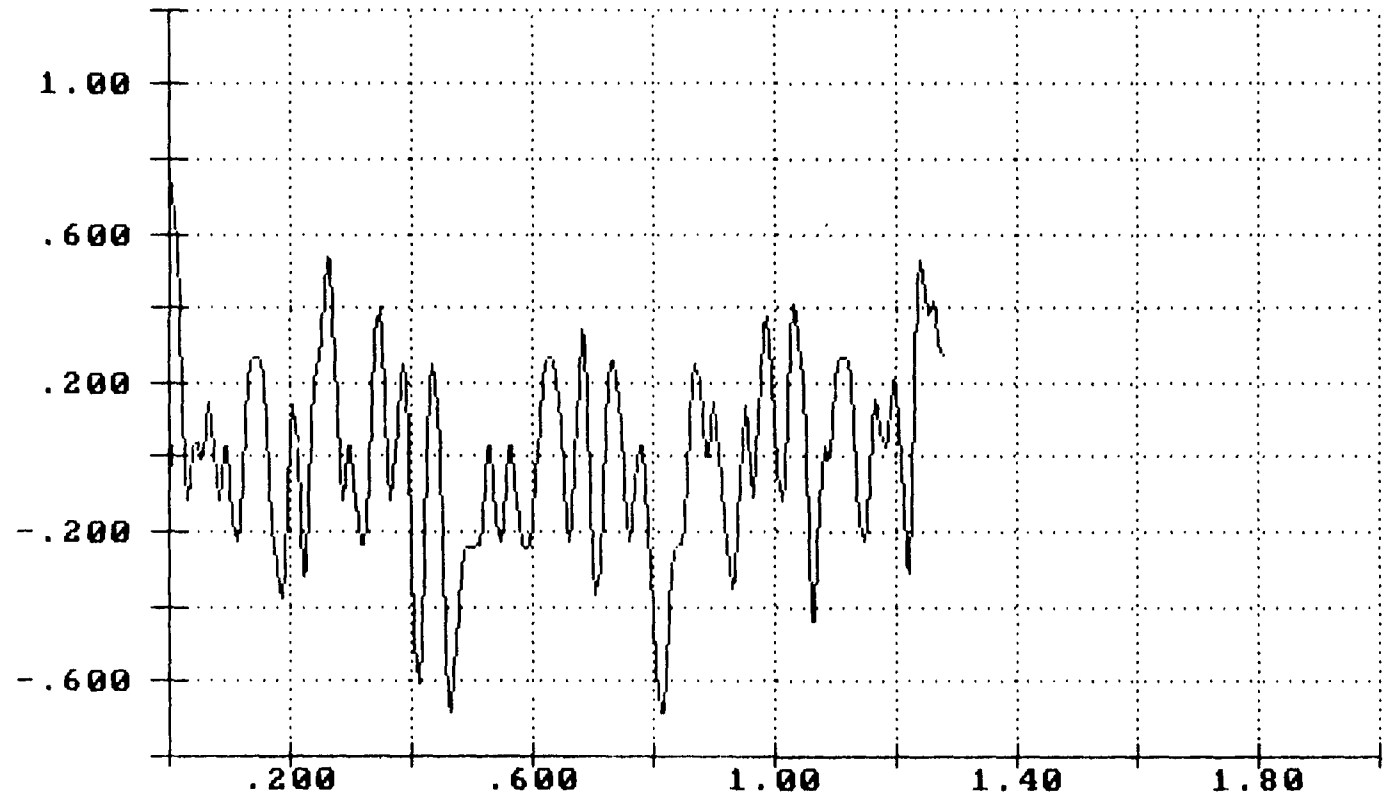
RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 1)



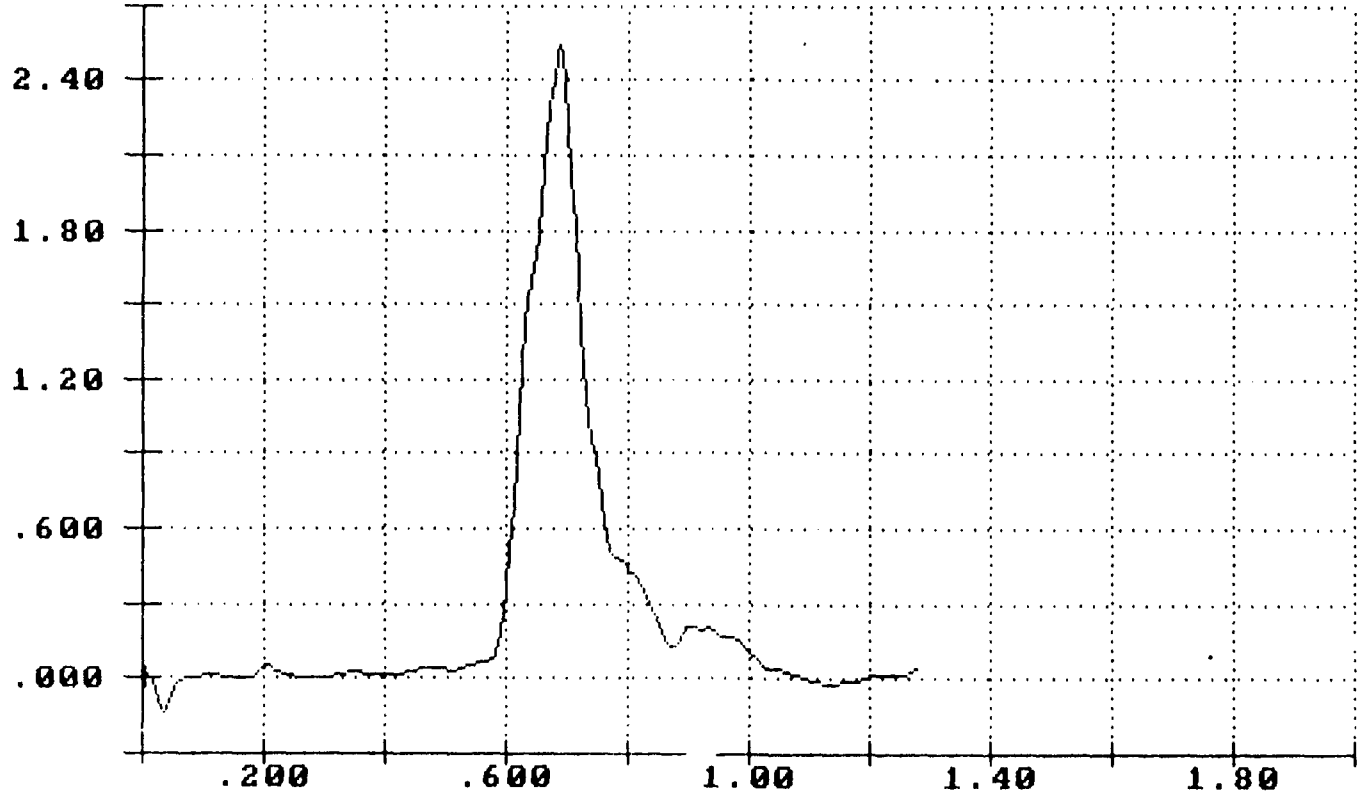
RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 1)



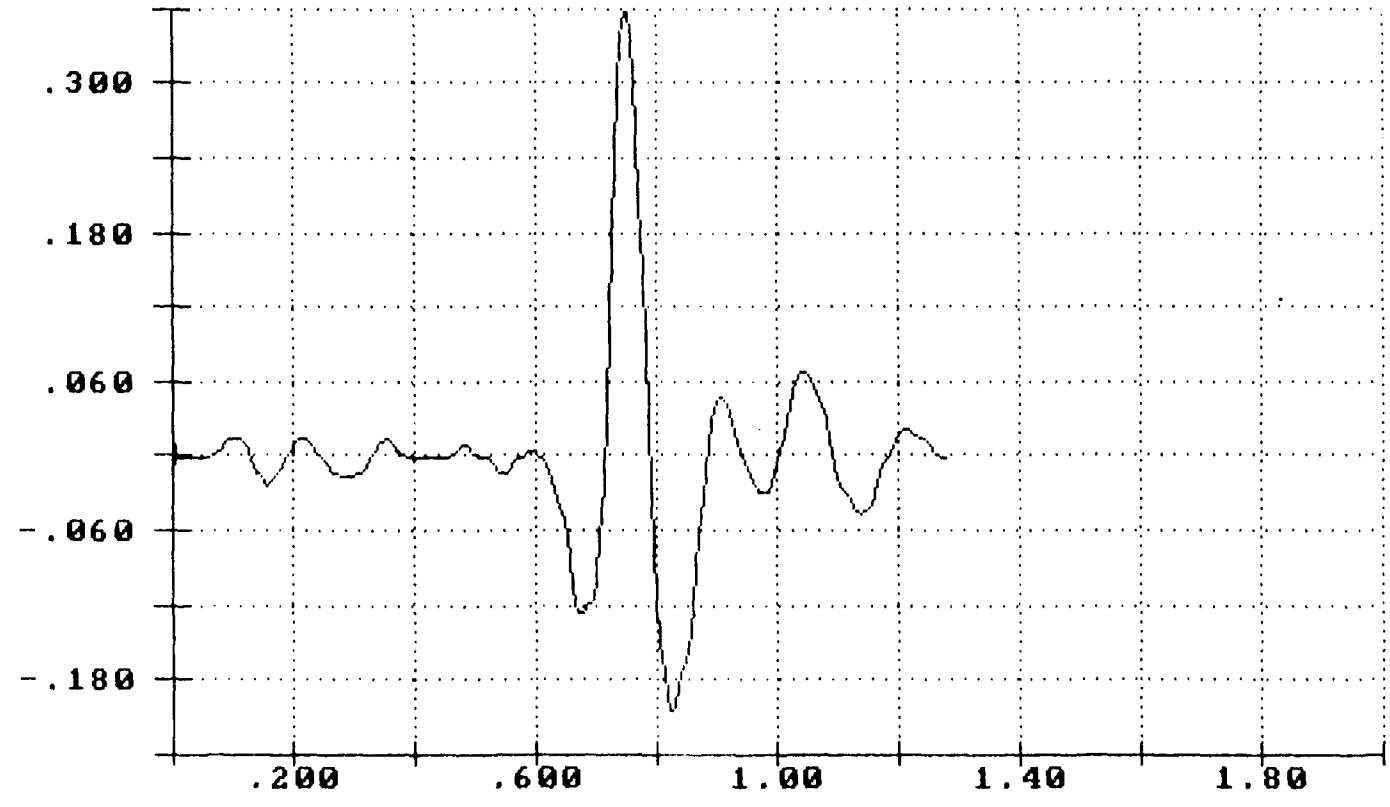
RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 1)



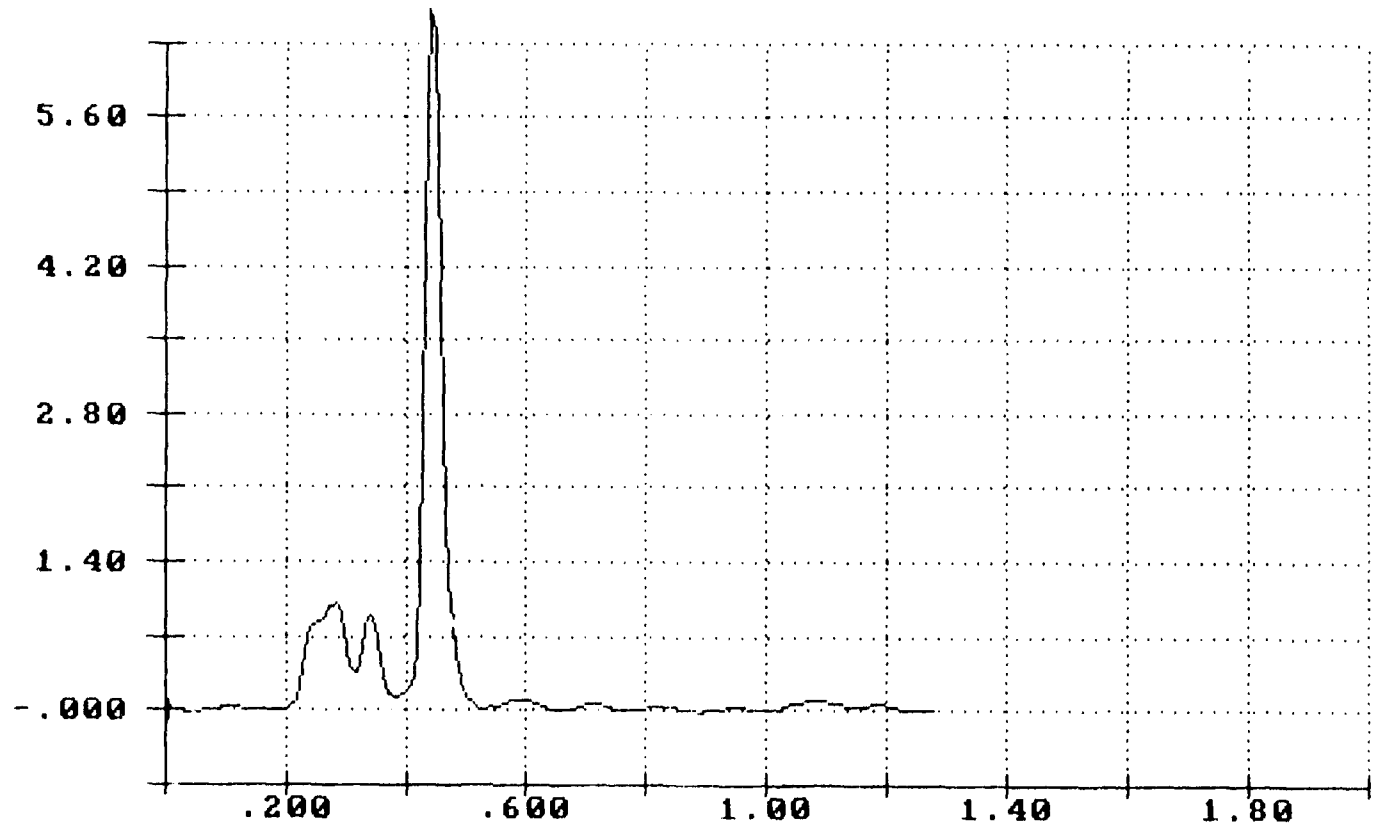
RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 1)



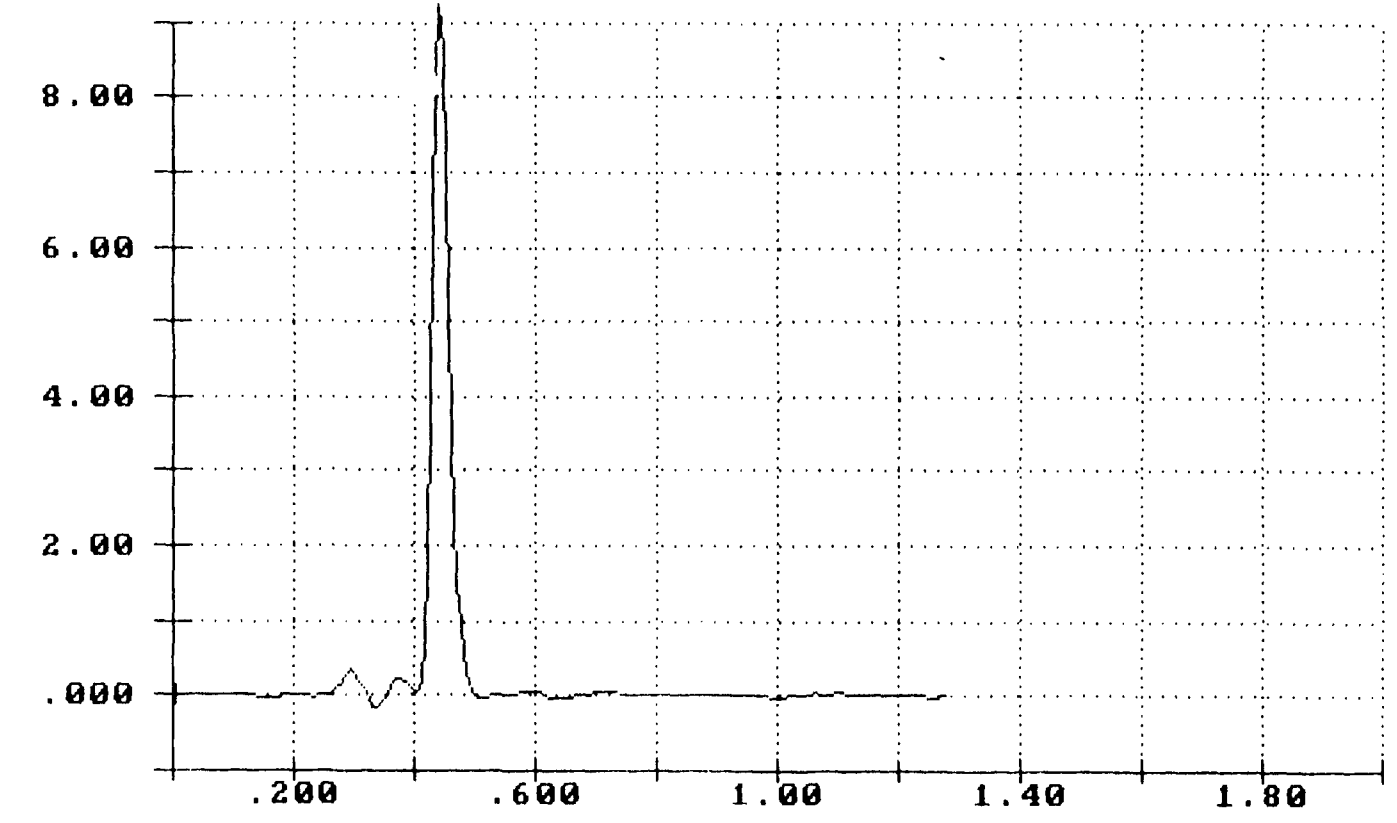
RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 1)



RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 2)

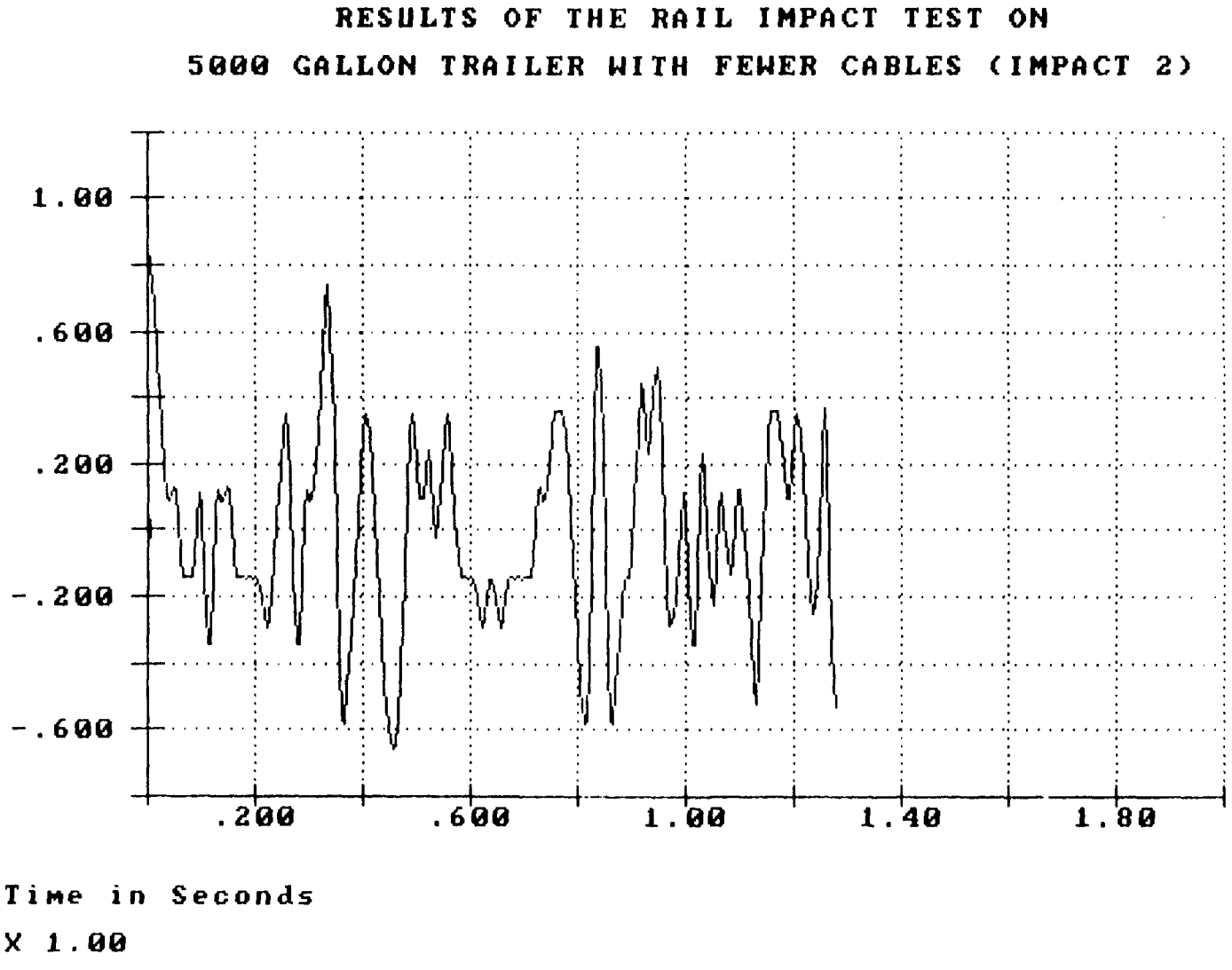


RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 2)

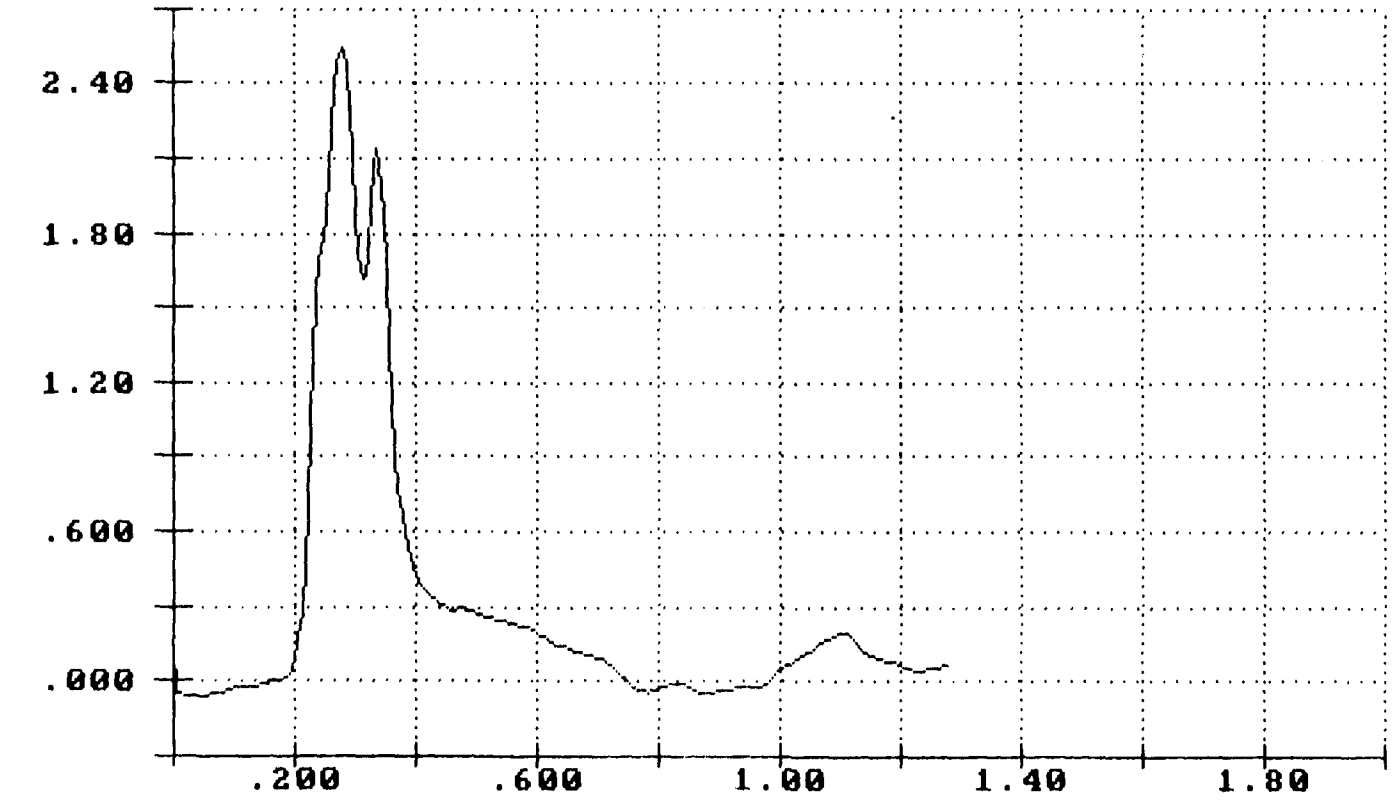


VERTICAL ACCELERATION ON SILL
IN G'S X 1.00

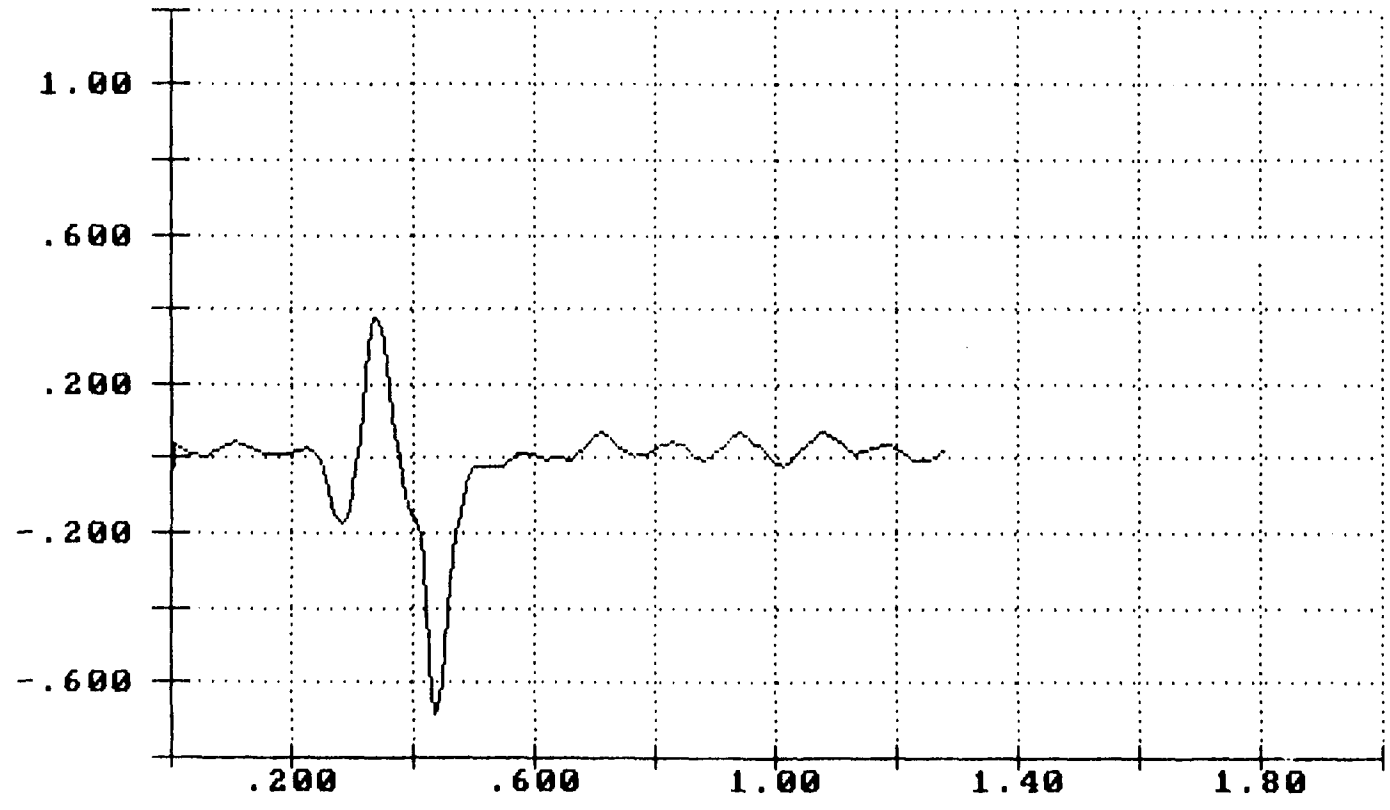
Time in Seconds
X 1.00


RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 2)
1.00
.600
.200
-.200
-.600
.200
.600
1.00
1.40
1.80
LONGITUDINAL ACCELER-
ATION ON TANKER FRAM
IN G'S X .01
Time in Seconds
X 1.00

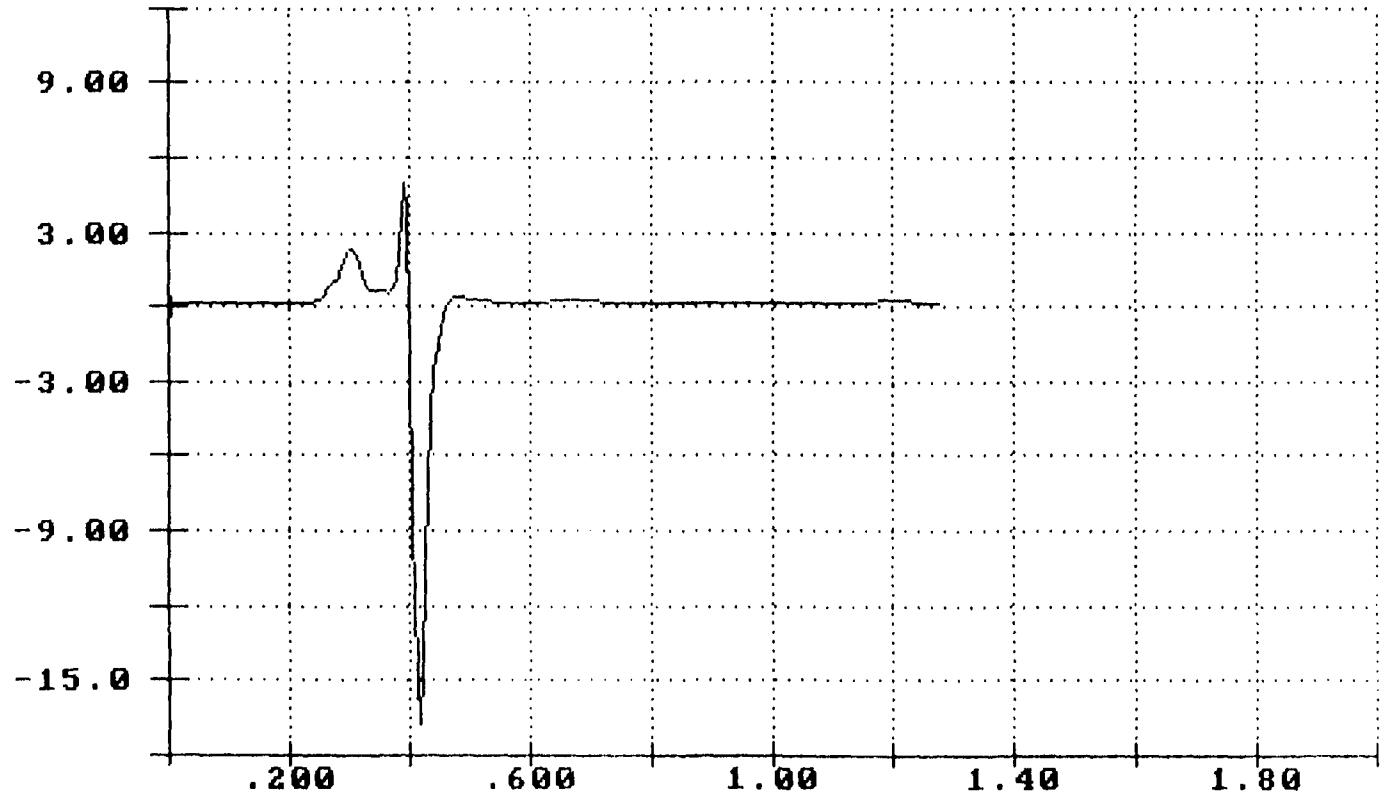
RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 2)



RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 2)



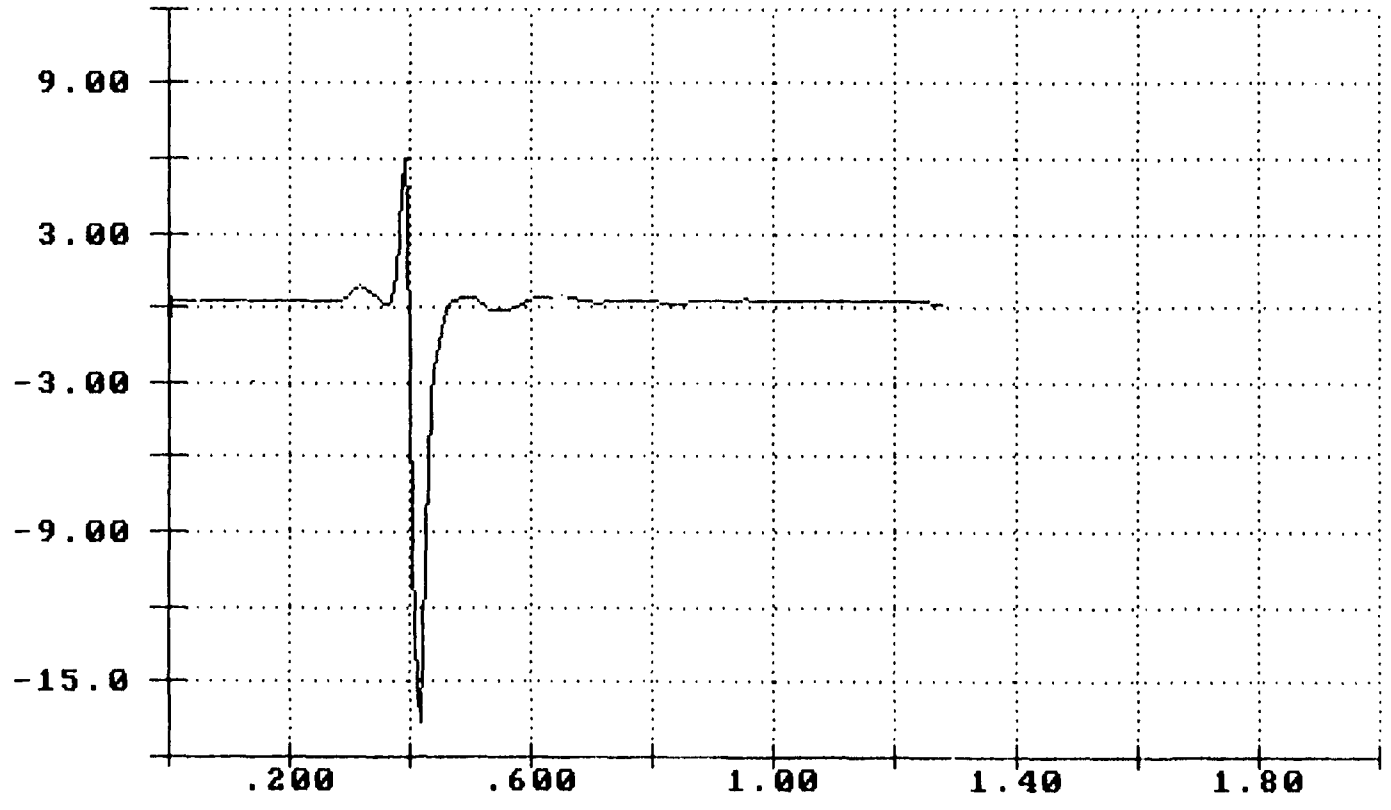
RESULTS OF THE RAIL IMPACT ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 3)



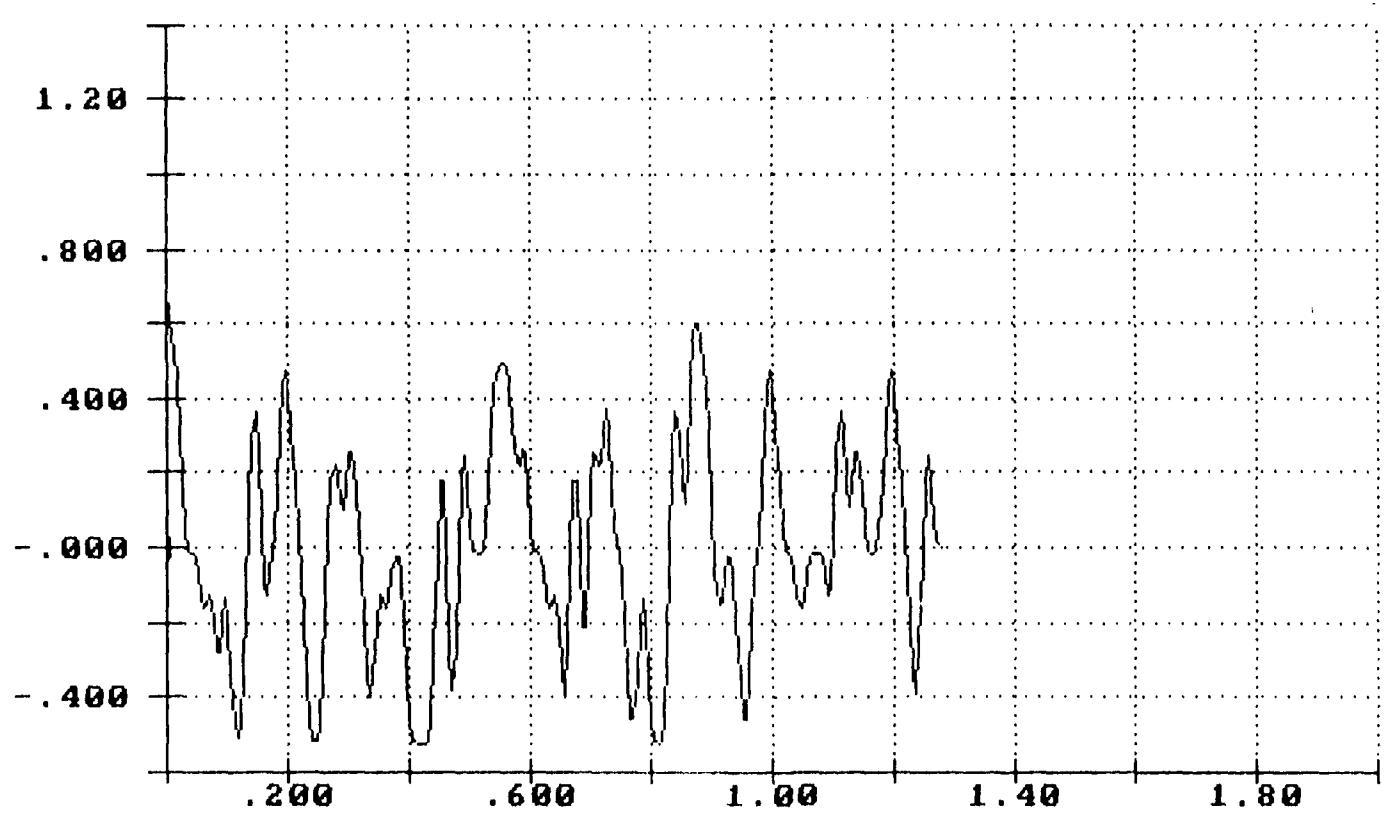
LONGITUDINAL ACCELERATION ON SILL IN G'S X 1.00

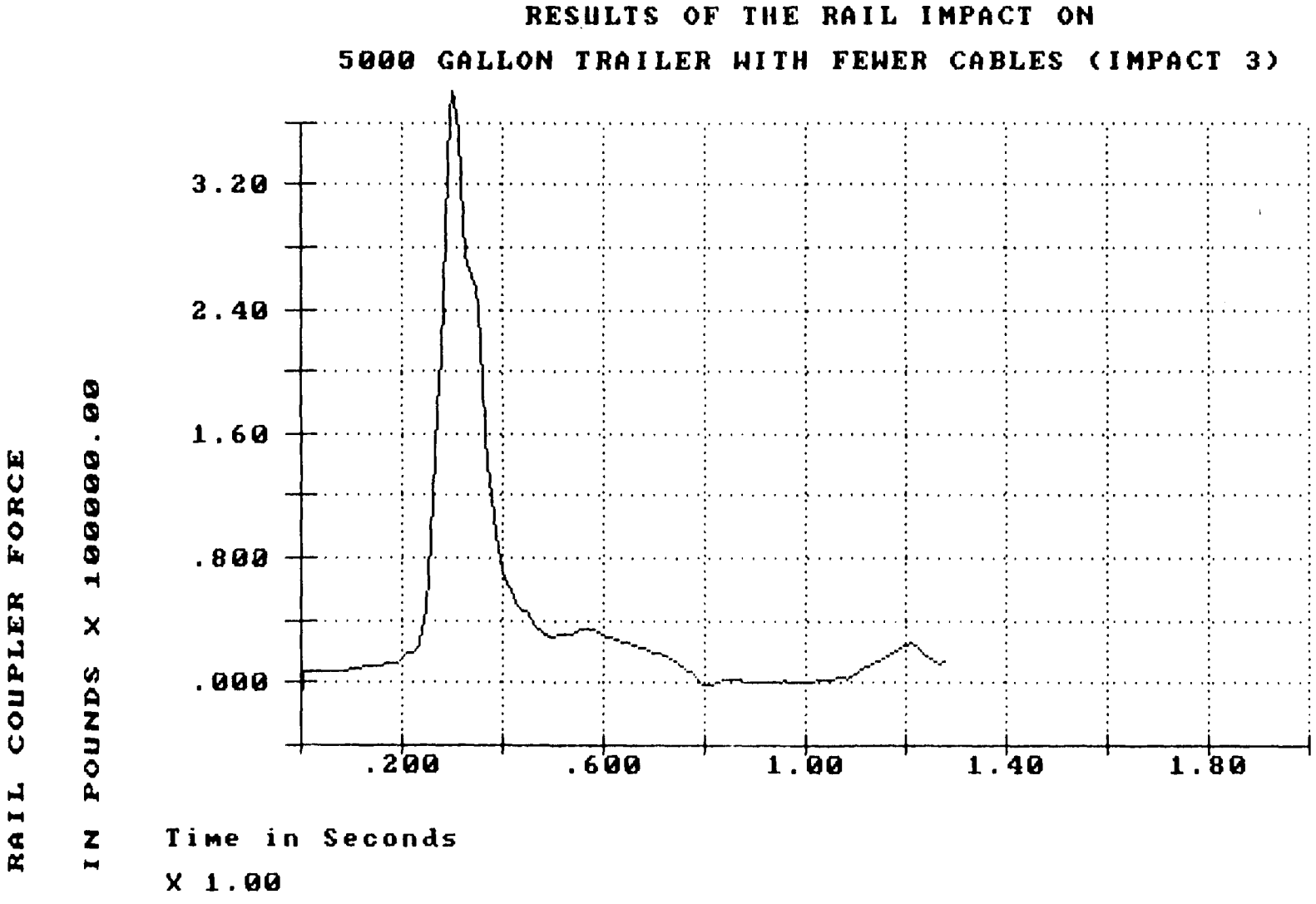
Time in Seconds
X 1.00

RESULTS OF THE RAIL IMPACT ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 3)

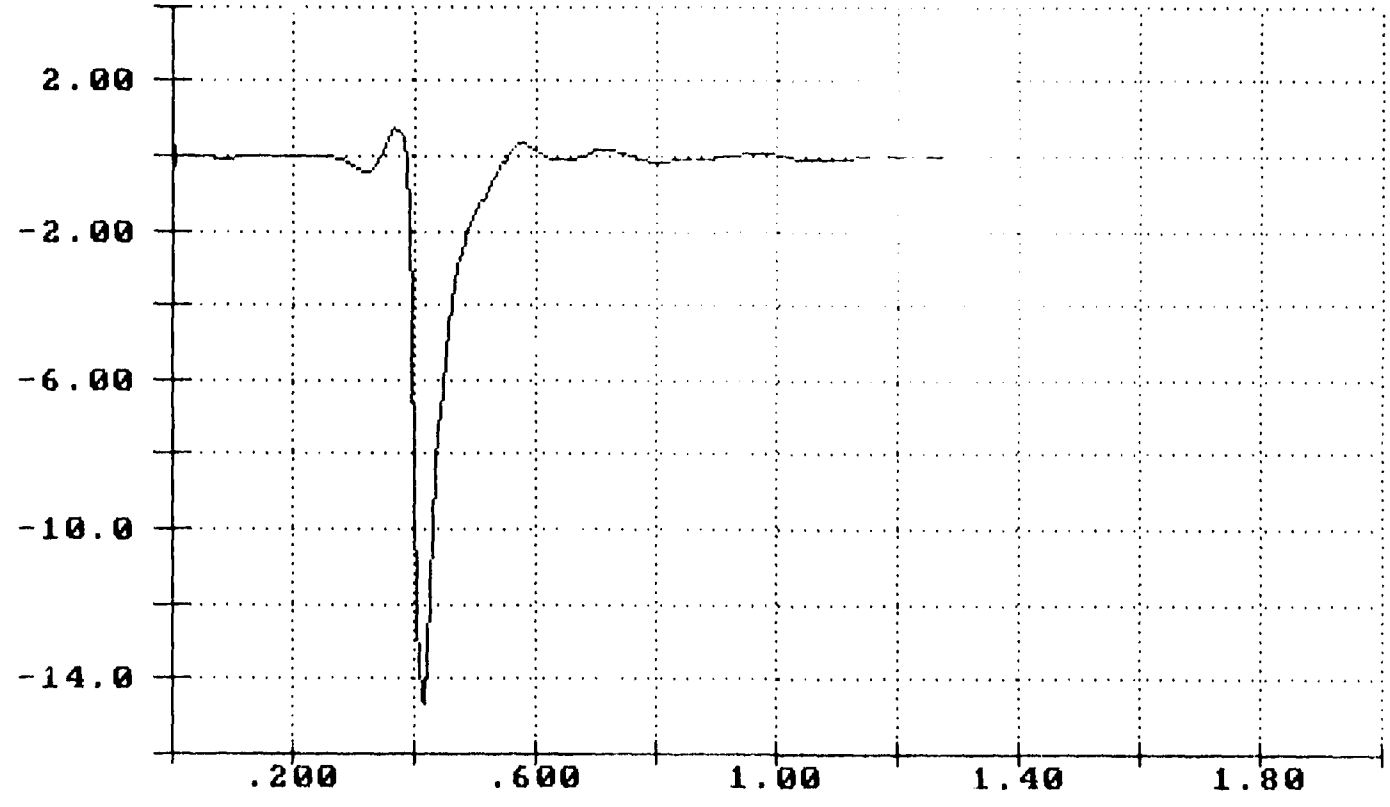


RESULTS OF THE RAIL IMPACT ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 3)




RESULTS OF THE RAIL IMPACT ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 3)
RAIL COUPLER FORCE
IN POUNDS X 100000.00
3.20
2.40
1.60
.800
.000
.200
.600
1.00
1.40
1.80
Time in Seconds
X 1.00

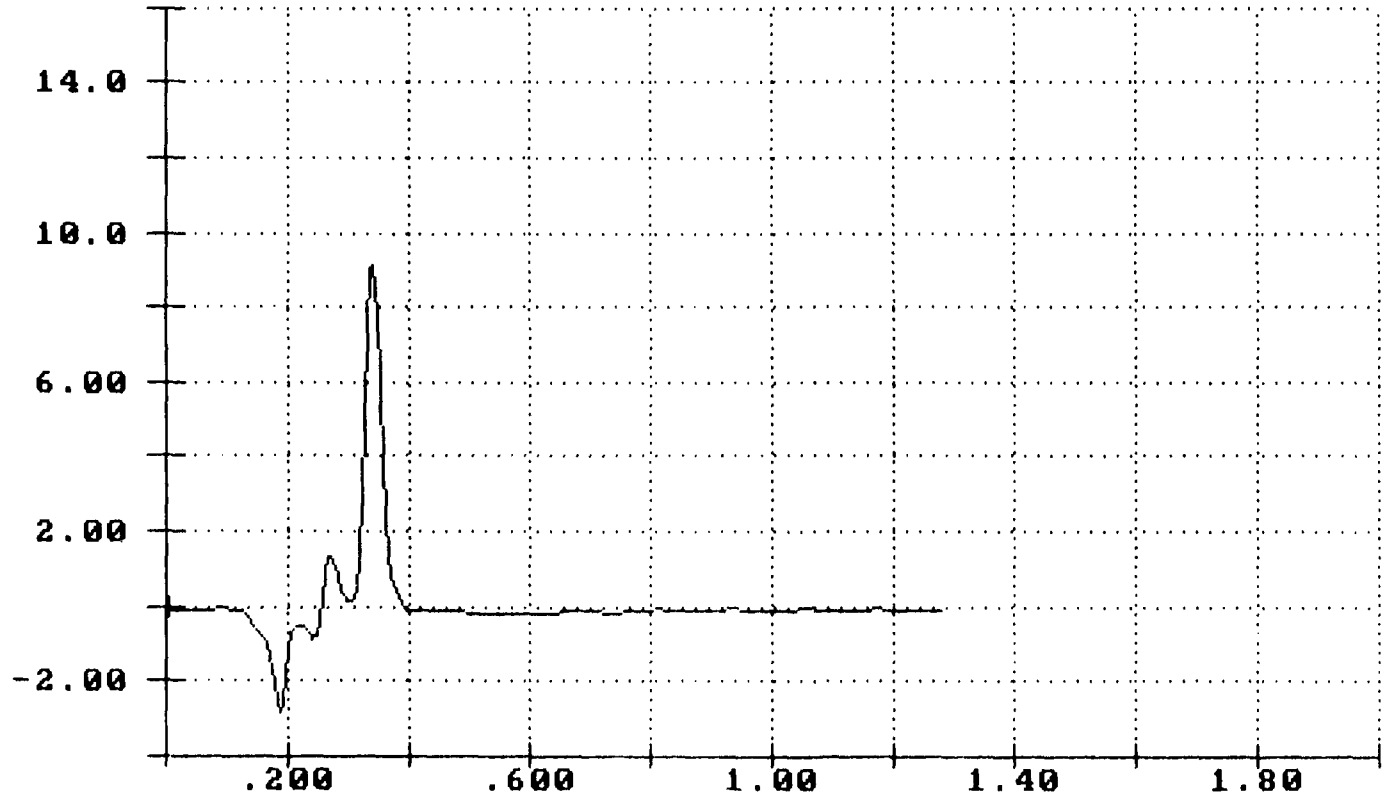
RESULTS OF THE RAIL IMPACT ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 3)

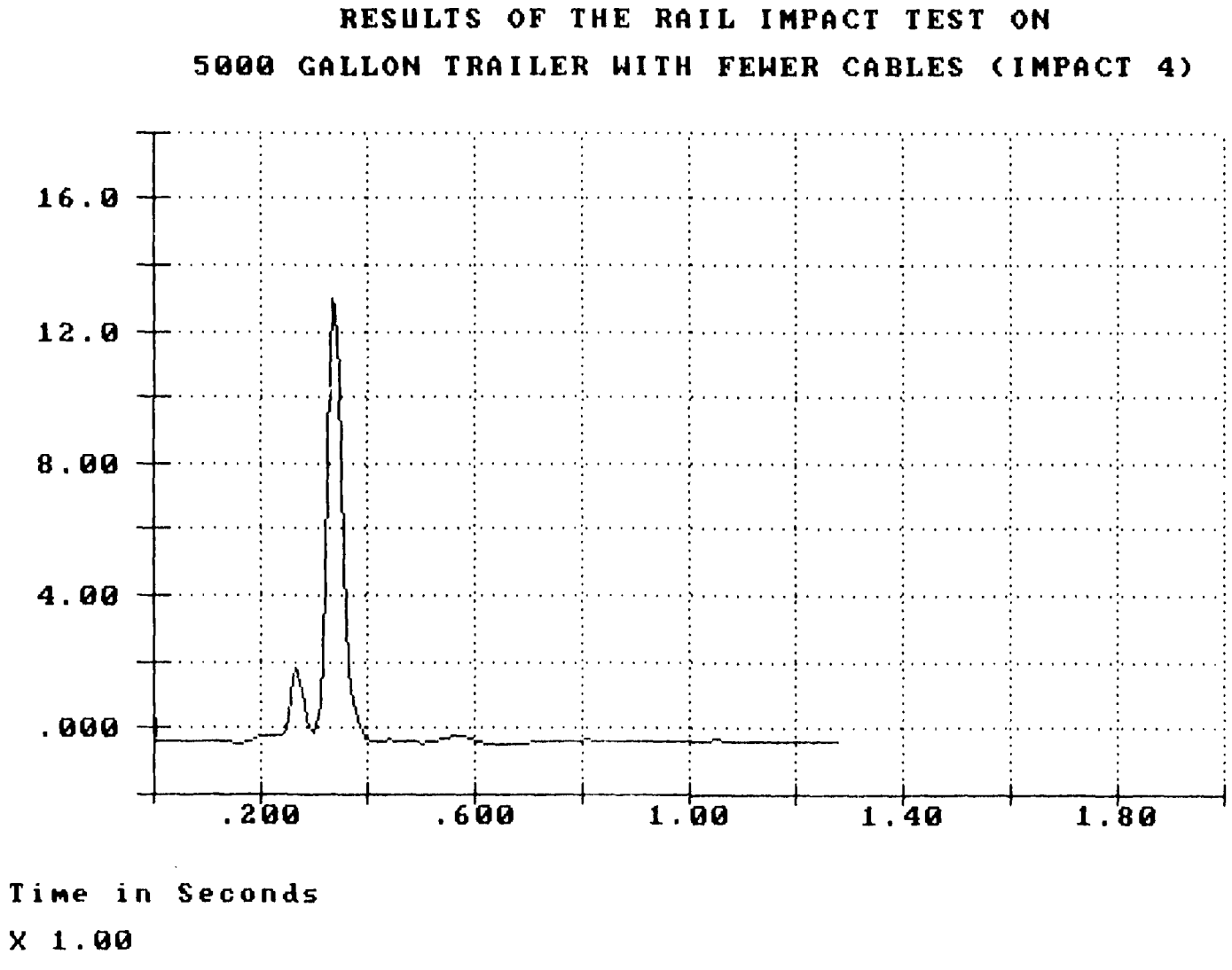


UERTICAL ACCELERATIO-
N ON TANKER FRAME
IN G'S X 1.00

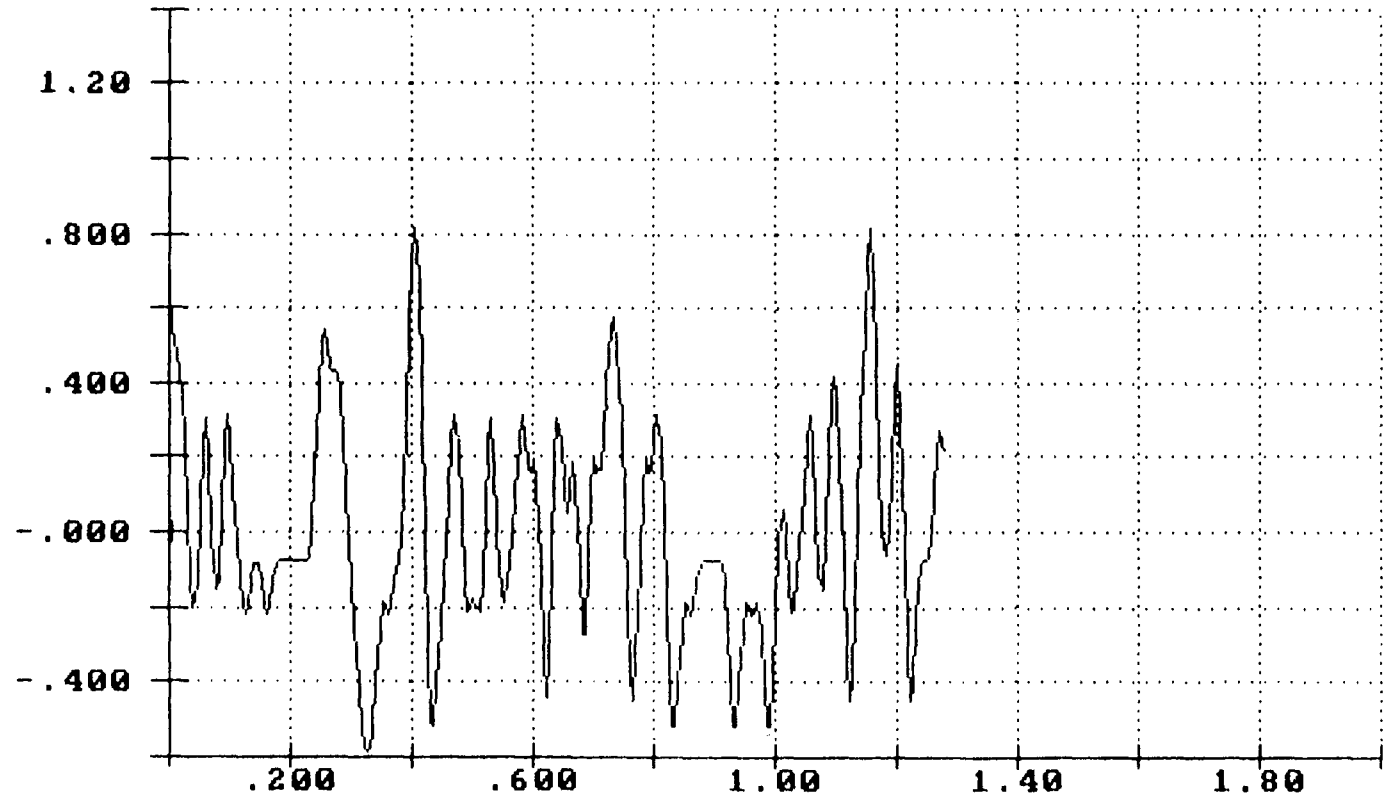
Time in Seconds
X 1.00

RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 4)




RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 4)
16.0
12.0
8.00
4.00
.000
.200
.600
1.00
1.40
1.80
UERTICAL ACCELERATIO-
N ON SILL
IN G'S X 1.00
Time in Seconds
X 1.00

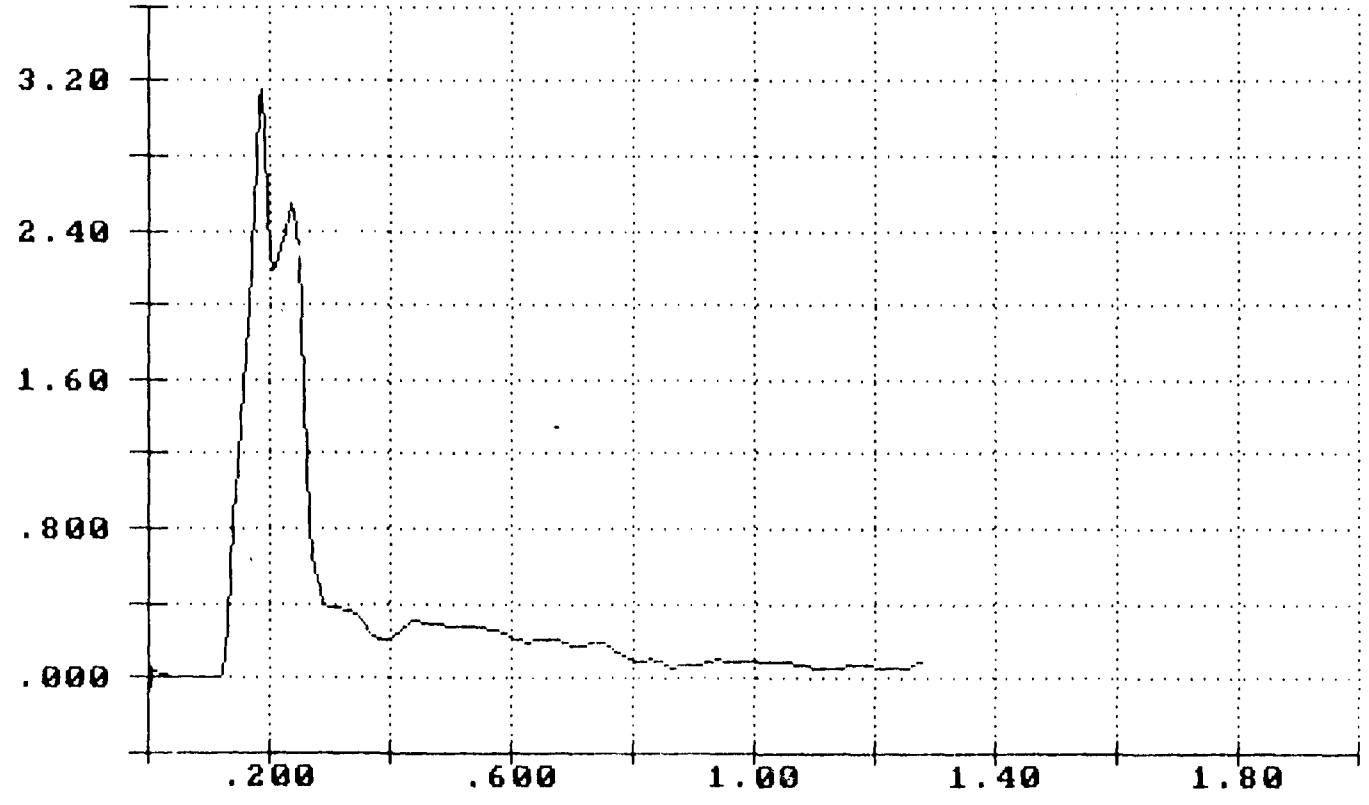
RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 4)



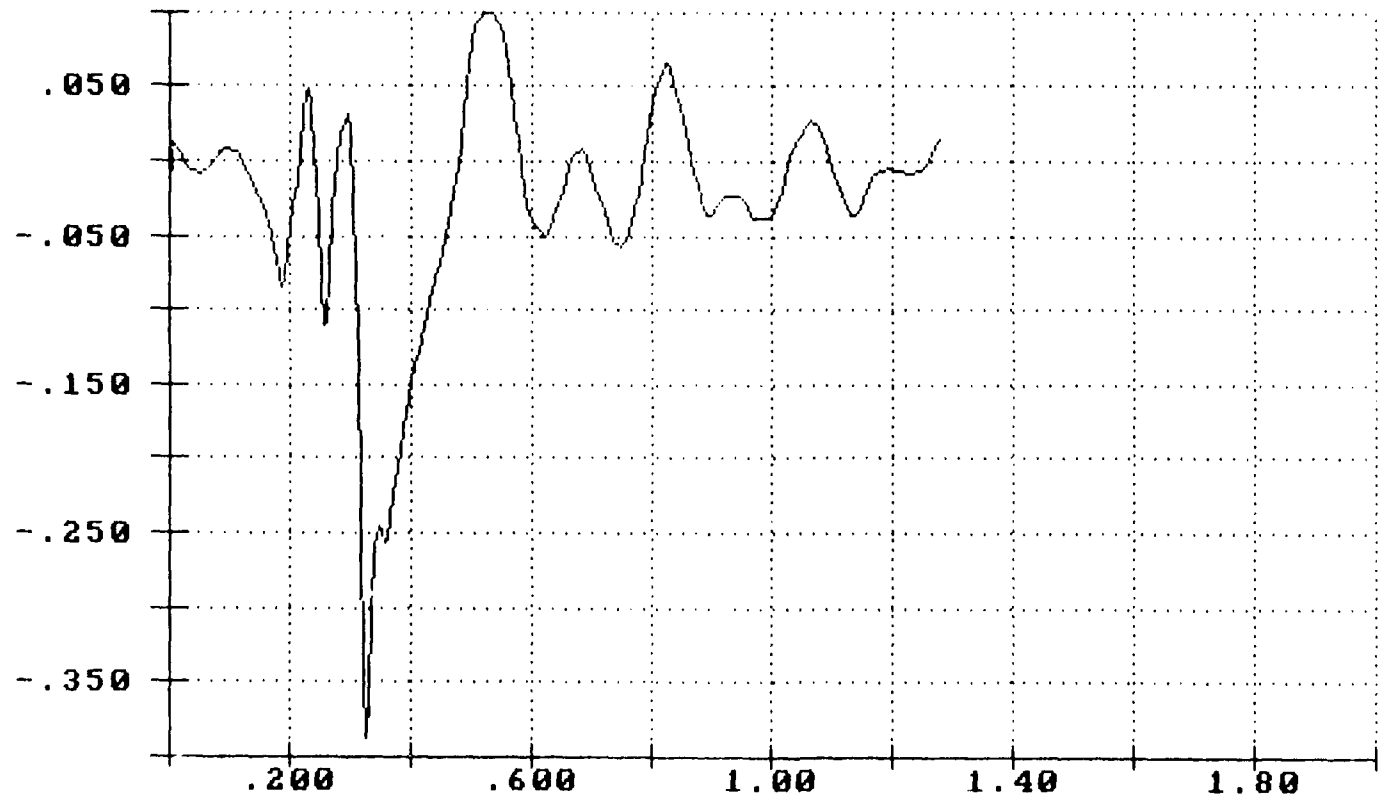
LONGITUDINAL ACCELER-
ATION ON TANKER FRAM
IN G'S X .01

Time in Seconds
X 1.00

RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 4)



RESULTS OF THE RAIL IMPACT TEST ON
5000 GALLON TRAILER WITH FEWER CABLES (IMPACT 4)



UERTICAL ACCELERATIO-
N ON TANKER FRAME
IN G'S X 1.00

Time in Seconds
X 1.00

PART 6

CONCLUSIONS and RECOMMENDATIONS

A. CONCLUSIONS

The M969A1 Fuel Tanker Semitrailer was tested for transportability on a railroad flatcar with friction draft gear. The tiedown procedure supplied by Barnes and Reincke, Inc., was satisfactory in restricting movement of the M969A1 Fuel Tanker and in preventing damage to any of the tiedown fittings. In order to make the tiedown procedure more efficient and economical, the four axle stands and four one-half inch cables were removed. The trailer was retested in accordance with the MIL-STD-810D requirements for rail transportation. No damage occurred to the M969A1 Fuel Tanker.

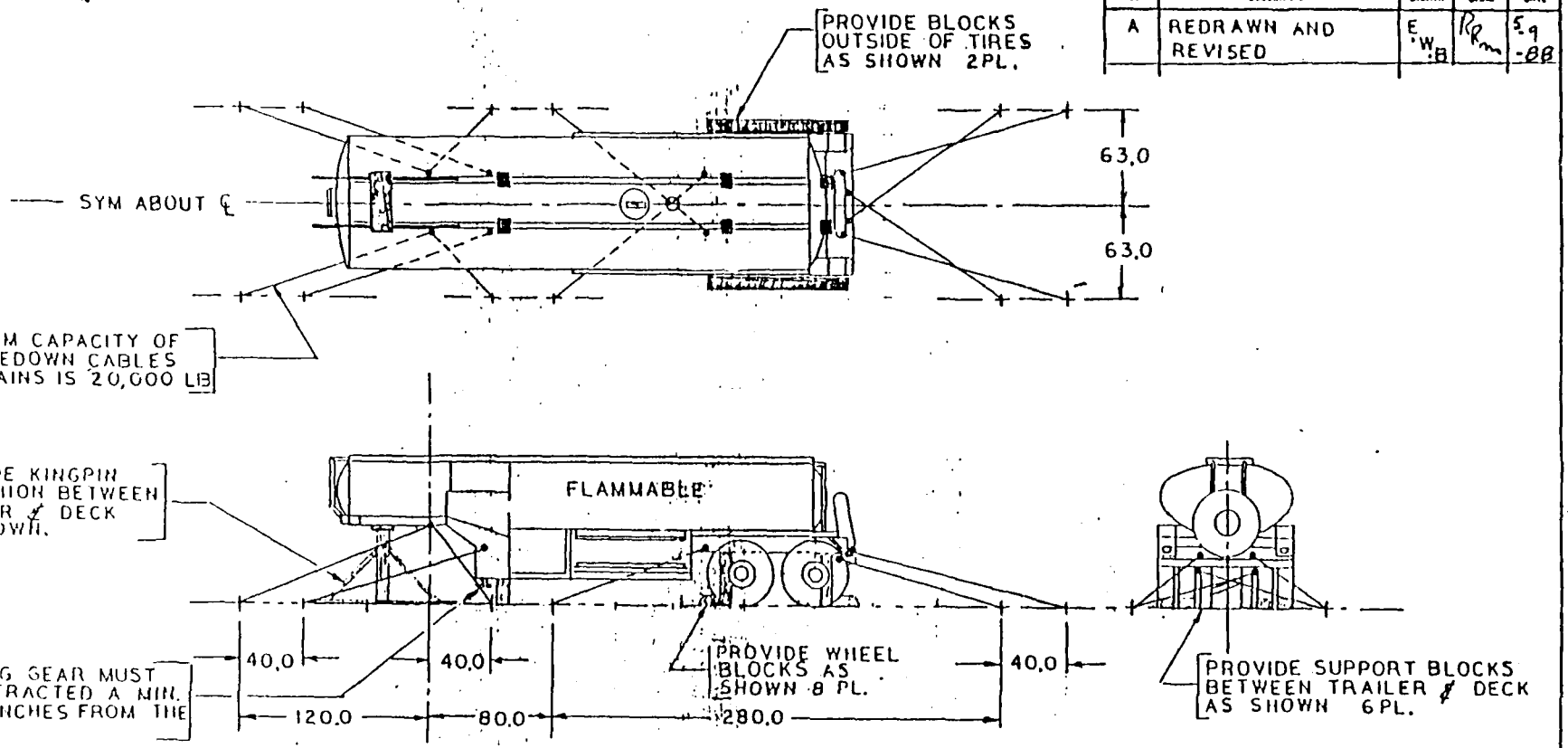
B. RECOMMENDATIONS

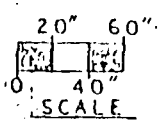
Based on the test results, it is recommended that the modified tiedown procedures for rail transportability of the M969A1 Fuel Tanker Semitrailer be used.

PART 7

TIEDOWN PROCEDURES

REV	DESCRIPTION	DRAWN	CHKD	DATE
A	REDRAWN AND REVISED	E.W.B	RRm	5-9-88





UNLESS SPECIFIED DIM TOLERANCES ARE: ± 6 IN.
ONE PLACE ± 1.5
TWO PLACE ± 0.6
THREE PLACE ± 0.25
ANGLES ± 1°
SURFACE FINISH ✓

ITEM	QTY	DESCRIPTION	REMARKS

THIRD ANGLE PROJECTION

MATL. & WT.

DRAWN	E.W.B	5-5-88
CHECKED	RRm	5-9-88
APPROVED		
SCALE	SHT SIZE	SHEET OF
NEXT ASSEMBLY		

TIEDOWN INSTRUCTIONS FOR RAIL TRANSPORT

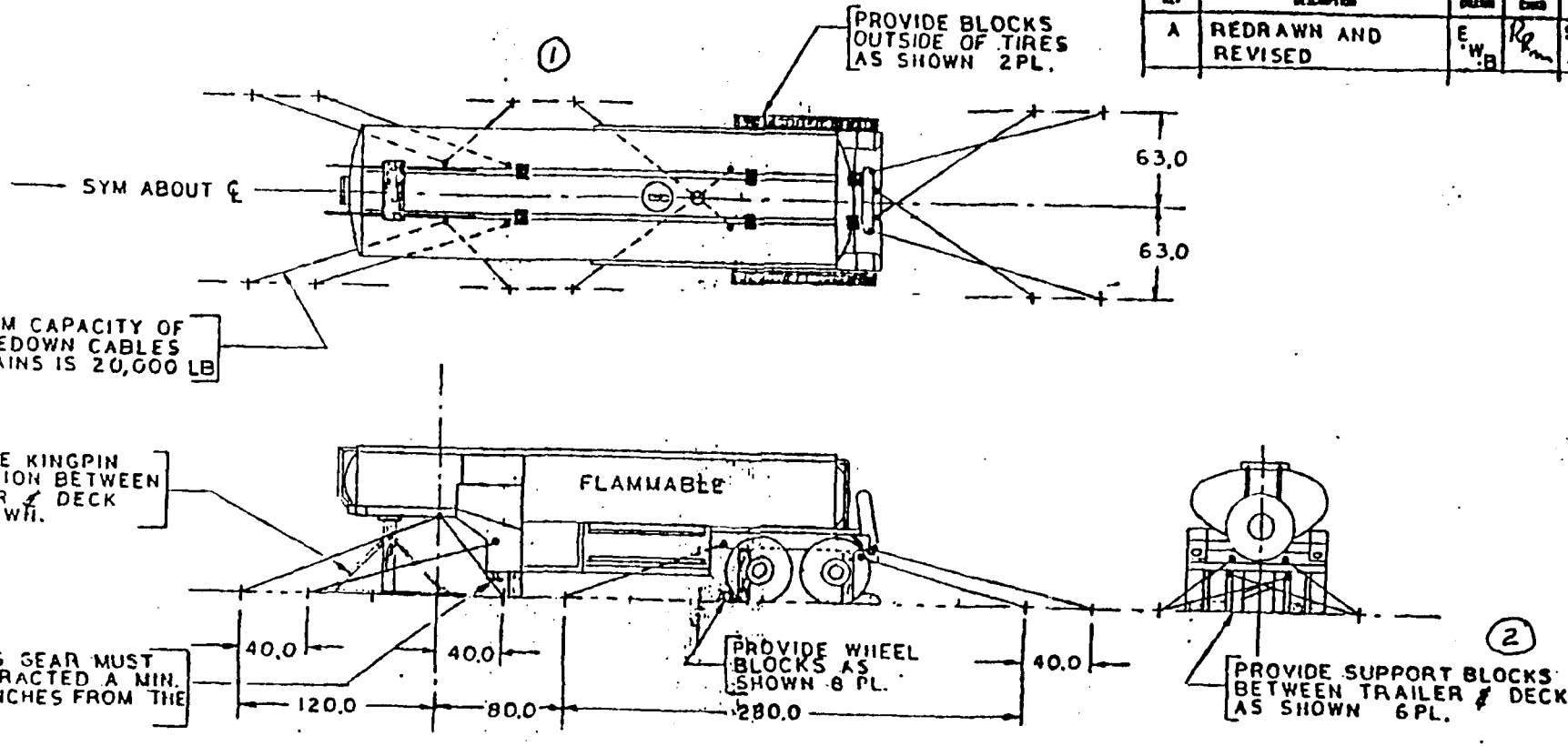
M967/A1, M969/A1, M970/A1

PROJECT NUMBER 800-124

REVISION

Barnes & Reinecke, Inc.

REV	DESCRIPTION	DRAWN	CHKD	DATE
A	REDRAWN AND REVISED	E.W.B	RR	5-9-88



NOTES:

(1) REVERSE CABLES REMOVED

(2) AXLE BLOCKING REMOVED

20" 60"
0 40"
SCALE

UNLESS SPECIFIED DIM TOLERANCES ARE: ± 6 IN. ANGLES ± 1° ✓

THIRD ANGLE PROJECTION

DRAWN	E.W.B	5-5-88
CHECKED	RR	5-9-88
APPROVED		
MATL & H.T.	SCALE —	SHT SIZE
NEXT ASSEMBLY		SHEET OF

ITEM	QTY	DESCRIPTION	REMARKS

TIEDOWN INSTRUCTIONS FOR RAIL TRANSPORT

M967A1, M969A1, M970A1

PROJECT NUMBER 800-124